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STUDY OF MELT LOADING THE 105 MM M1 PROJECTILE WITH COMP B CONTAINING GRADE B WAX

Robert Pelien, et al

Picatinny Arsenal
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ROBERT PELLEN
KENNETH RUSSELL

SEPTEMBER 1975

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A process and material variables program was implemented to resolve production loading problems with the 105mm M1 shell. When Composition (Comp) B with Grade B wax was substituted for Comp B with Grade A wax, many of the explosive casts upon solidification contained cavities defined as critical defects. Comp B with three types of Grade B waxes, and one with Grade A wax were studied. The test variables consisted of explosive and shell temperature; effect of SPAN 85; water cooling; skid shroud design; shell position analysis;

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effect of hot top-off; probing; split pouring; viscosity; laboratory tests; and others. From the tests it was determined that shell temperature before pour, and explosive temperature at pour are the most significant variables. By restricting shell temperature to a range of 65° to 79°F, the explosive pour temperature to 176° ± 3°F, Comp B with Petrolite (ES670) or Indramic (170C) wax was used successfully on a regular production basis. Comp B using Castor wax was not successfully loaded within the limits. Use of SPAN 85, a surfactant was not helpful. A temperature variable study with Comp B using Sunoco 8810 (Grade A) showed that this material behaves quite differently and that shell temperatures in excess of 90°F can be tolerated. More effective shrouding of a poured skid is considered to be helpful, but not a prime factor. Other process variables, i.e., agitation, scrap level, riser height, cooling bay temperature, reservoir level, and skid temperatures, are judged to have some significance but are not prime factors. However, all of these are subtle factors in the sense they relate to an objective of maintaining a reproducible, controllable process.

ACKNOWLEDGMENTS

The authors gratefully wish to acknowledge the high degree of cooperation in this study and in other activities of the ad hoc committee with the 105mm loading problems, on the part of JAAP, in particular Mr. H. Miller, Mr. M. Shrode, and Mr. K. Blanchard.

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SECTION I

INTRODUCTION

1. INTRODUCTION.

This report covers a series of process variables and material variable loading trials performed on over 40,000 shells at Joliet Army Ammunition Plant (JAAP) with the 105mm M1 projectile using a Comp B explosive fill. The work was undertaken as a result of extreme production difficulties when Comp B with Grade B wax was introduced into 105mm M1 loading operations during 1973.

1.1 PURPOSE.

There were two prime objectives for the work undertaken at JAAP.

1. To establish a suitable process for loading Comp B with Grade B wax in the 105mm projectile.
2. To obtain data that would provide more information about the 105mm melt loading problems, and provide a data base for laboratory efforts and analytical work at other facilities on the 105mm melt loading problems.

1.2 BACKGROUND.

Grade A desensitizing wax (primarily Sunoco 8810) was used for many years as the desensitizing wax in Comp B. In the recent past, sources of Grade A wax have no longer been available, and various Grade B waxes (primarily Indramic 170C and Petrolite ES670) have been used to manufacture Comp B. When Comp B with these Grade B waxes was introduced into the 105mm M1 loading operations at Kansas Army Ammunition Plant (KAAP) in the early spring of 1973, and later at JAAP, numerous cavitation defects in the "C" segment of the explosive cast occurred. The occurrence of these defects necessitated frequent and costly 100 percent radiographic inspection of the cast projectiles, and eventually necessitated return to loading with rapidly dwindling stocks of Comp B with Grade A wax.

An ad hoc committee was formed to resolve these problems, and the loading plant trials encompassed in this report is one phase of the effort coordinated by this committee. Other phases of the overall program included 1) lab-

oratory work to characterize a large number of waxes and wax-like materials as possible substitutes, 2) loading trials with instrumented shell, 3) computer analysis to obtain a better understanding of melt pouring and the cooling cycle, 4) analysis of the significance of differing impurities in batch or continuous process TNT, 5) loading studies with other ammunition items at other load plants. These other programs are not covered in this report but are mentioned occasionally in the discussion.

Generally, Comp B with Grade B waxes did not cause undue problems in other projectiles. The reasons are either a different size and configuration such that the cooling cycle is not critical, or the item receives a 100 percent radiographic inspection which eliminates cavitation from production. Thus, the 105mm M1 shell, by dint of size, configuration, and large volume production became the focal item for the "wax problem" in Comp B loading.

The time period for the loading plant trials conducted at JAAP was August through November 1973. The report quantifies and identifies process variables and their effect on production and presents the results of loading trials conducted on a production scale. These tests were conducted by JAAP production and engineering personnel, in conjunction with Picatinny Arsenal resident engineers. A full scale production line known as Group 3 was used for all loading trials.

All projectiles used in the loading trials were manufactured by National Presto. All Comp B was produced at Holston AAP. The new waxes used were Petrolite ES670. Indramic 170C and Castor wax. The specification for the 105mm M1 cartridge (MIL-G-45195C) was the document used to define acceptable explosive cast quality.

Joliet AAP returned to full production use of Comp B with Grade B wax on 26 September 1973. Production has used Comp B with both Petrolite ES670 and Indramic 170C wax. This has continued to date, and has been successful. Return to successful full production resulted from implementation of established control limits on shell and explosive temperature, and the manufacture and use of a more efficient shroud assembly.

1.3 REPORT ORGANIZATION.

This report is comprised of six sections; and four appendices:

Section I	Introduction.
Section II	Process Tests and Studies - discusses the process and material tests, test procedures, and results.
Section III	Laboratory Tests - discusses laboratory analysis of Comp B for wax content, RDX content, and density.
Section IV	Production Process Comments - discusses in general terms the process variable effects on cast loading of the 105mm M1 shell.
Section V	Conclusions.
Section VI	Recommendations.
Appendix A	Cavitation Requirements.
Appendix B	Projectile Weight Study.
Appendix C	Physical Property Data.
Appendix D	Test Data - provides detailed test procedures and results of test groups A through Q.

Table I provides a list of symbols used in this report.

TABLE I

LIST OF SYMBOLS

Symbol	Description
○	Skid with no defects (used on figures 2 thru 8, 10 and 11).
△	Skid with defects - number inside or outside triangle indicates number of defects per skid. (Used on figures 2 thru 8, 10 and 11).
●	Solid Circle - High defect position or cavity (Used on figures 16, 17, 18, 19 and 28).
◒	Semi-solid circle - Low defect position (Used on figure 28).
⊙	Air Temperature around risers in center of skid (Used on figures 23 through 26).
⊡	Outside temperature of shell at a point 6.5 inches from base (Used on figures 23 through 26).
⟐	Outside temperature of shell immediately above rotating band (Used on Figures 23 through 26).

SECTION II

PROCESS TESTS AND STUDIES

2. GENERAL.

When this program was initiated there were two goals established. The first and most immediate goal was to find a satisfactory process to cast acceptable 105mm shells with Comp B manufactured with Grade B wax (See Figure 1). The second goal was to define the significant variables in the process, and to obtain better insight to cast loading variables and problems. In pursuit of these goals, the first variables studied were shell and explosive temperature.

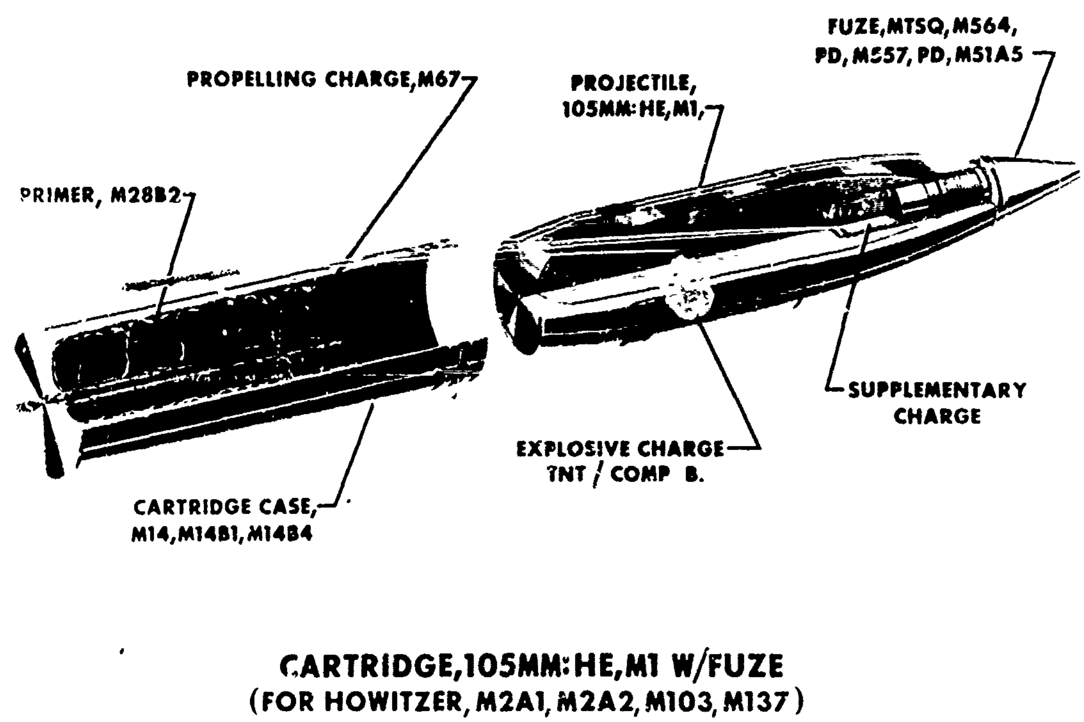


Figure 1. 105mm M1 Configuration

2.1 GRIDDING.

When the test program was initiated, it was thought necessary to have quantitative means to evaluate the size of cavities, in lieu of "critical", "minor" or "less than minor" as specified by the cartridge specification. A method was established to overlay the X-ray film with a transparent grid and count the blocks the cavity encompassed. This method yielded quantitative results, but was time consuming. As testing progressed, it became apparent that occurrence of cavitation was either considerable, or non-existent; and a more precise quantitative evaluation did not assist in evaluation of X-ray results. After several tests, gridding was discontinued and specification criteria for defects was used for the remaining tests.

2.2 EXPLOSIVE AND SHELL TEMPERATURE STUDY.

2.2.1 Temperature Variables for Grade B Waxes.

A temperature variable study was performed on Comp B manufactured with the following waxes:

1. Petrolite ES 670 wax (Grade B)
2. Indramic wax 170C (Grade B)
3. Castor wax (Grade B)

The initial results of the Grade B studies are given in Tables II through V. These tables show the nominal temperatures and actual temperatures for each skid. The number of defective shells produced for each skid is also shown (full skid has 60 shells).

Table II. SUMMARY OF RESULTS FOR TESTS A-1 THRU A-9, PETROLITE WAX VIRGIN MATERIAL

Nominal Shell Temperature °F												
	70°F				80°F				90°F			
No. Exp Temp °F	No. of Def*	Def Area	Actl Shell Temp	Actl Exp Temp	No. Def	Def Area	Actl Shell Temp	Actl Exp Temp	No. of Def	Def Area	Actl Shell Temp	Actl Expl Temp
176	0	0.0	78	174	8	179.5	82	176	14	264.0	90	176
	0	0.0	72	173	2	42.0	82	176	12	244.0	90	176
	1	14.0	73	172	2	59.0	80	176	15	313.0	93	176
	0	0.0	70	174	1	17.5	80	176	43	674.0	90	176
178	0	0.0	75	180	0	0.0	80	177	42	862.5	92	182
	1	26.5	70	180	0	3.0	82	177	40	871.5	92	180
	0	0.0	70	179	0	3.0	80	179	12	224.5	91	182
	0	0.0	69	180	0	2.0	81	179	13	182.0	90	180
184	3	78.0	70	183	2	57.5	80	185	30	734.0	92	183
	1	37.5	75	185	0	0.0	80	183	42	213.5	92	183
	0	0.0	75	185	0	0.0	80	184	34	860.0	92	184
	0	0.0	77	182	1	24.5	80	181	46	961.0	93	183

*Defect

TABLE III. SUMMARY OF RESULTS FOR TESTS J-1 THRU J-4, INDRAMIC WAX VIRGIN MATERIAL

Nominal Shell Temperature °F						
	70°F			90°F		
Nom Exp Temp °F	Number of Defects	Actual Shell Temp	Actual Exp Temp	Number of Defects	Actual Shell Temp	Actual Exp Temp
176	0	72	175	2	92	175
	0	71	176	16	92	176
	0	71	176	15	93	176
	0	72	175	21	93	176
184	0	72	186	47	90	188
	0	71	186	52	90	187
	0	70	185	57	93	189
	0	70	183	56	94	188

TABLE IV. SUMMARY OF RESULTS FOR TESTS J-17 THRU J-21, INDRAMIC WAX CONTAINING 40% SCRAP

Nominal Shell Temperature °F						
	75-79°F			80-85°F		
Nom Exp Temp °F	Number of Defects	Actual Shell Temp	Actual Exp Temp	Number of Defects	Actual Shell Temp	Actual Exp Temp
180	0	78	180	0	85	180
	0	76	180	0	84	180
	0	75	181	1	85	180
	0	76	180	0	84	180
	0	76	179	0	82	180
184	0	76	182	6	84	184
	0	76	184	3	83	185
	0	77	184	1	84	185
	0	76	183	13	84	184
	4	78	183	1	82	184

TABLE V. SUMMARY OF RESULTS FOR TESTS F-1 THRU F-4, CASTOR WAX VIRGIN MATERIAL

Nominal Shell Temperature °F						
	70°F			90°F		
Nom Exp Temp °F	Number of Defects	Actual Shell Temp	Actual Exp Temp	Number of Defects	Actual Shell Temp	Actual Exp Temp
176	0	70	179	10	92	176
	0	72	177	0	93	174
	0	69	176	1	92	174
	0	74	176	3	92	175
184	0	70	185	15	93	182
	0	70	186	11	90	182
	1	70	186	24	92	184
	0	70	187	19	92	184

2.2.1.1 Variance Analysis, Grade B Waxes.

An analysis of variance for a two way classification was performed on these results. The results for these analyses are shown in Tables VI through IX. From these analyses, it can be concluded that shell and explosive temperatures are significant variables in the production of good explosive casts. It should be pointed out that this was not true for all of the studies. Explosive temperature was found not to be statistically significant in the temperature variation study for Comp B manufactured with Indramic wax (when used with 40% scrap) and Petrolite wax. This was probably due to the fact, that in the shell temperature ranges chosen, material temperature was not significant. An F value larger than F statistic indicates significance. An F value smaller than F statistic indicates lack of significance.

TABLE VI. ANALYSIS OF VARIANCE FOR PETROLITE WAX (BASED ON DEFECT COUNT)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	6127	2	3063	49.6	3.35
Exp Temp	178	2	89	1.44	3.35
Interaction Between Shell and Exp Temperature	445	4	111.25	1.80	2.75
Error	1666	27	61.7	--	
Total	8416	35	--	--	

TABLE VII. ANALYSIS OF VARIANCE TABLE FOR INDRAMIC WAX (VIRGIN MATERIAL)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	1560.2	1	1560.2	72.3	4.75
Exp Temp	4422.2	1	4422.2	204.9	4.75
Interaction Between Shell and Exp Temperature	1560.3	1	1560.3	72.3	4.75
Error	259.0	12	21.6	--	
Total	7801.8	15	--	--	

TABLE VIII. ANALYSIS OF VARIANCE TABLE FOR INDRAMIC WAX (CONTAINING 40% SCRAP)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	36.4	1	36.4	5.10	4.75
Exp Temp	22.0	1	22.0	3.08	4.75
Interaction Between Shell and Exp Temperature	18.0	1	18.0	2.52	4.75
Error	114.4	16	7.2	--	
Total	190.9	19	--	--	

TABLE IX. ANALYSIS OF VARIANCE TABLE FOR CASTOR WAX

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	196.0	1	196.0	15.22	4.75
Exp Temp	420.2	1	420.2	32.64	4.75
Interaction Between Shell and Exp Temperature	182.2	1	182.2	14.16	4.75
Error	154.5	12	12.88	--	
Total	953.0	15	--	--	

2.2.2 Figures 2 through 5 show the results of all skids which were single poured, not probed, or otherwise handled in a manner different from the original process, except an insulated wood shroud and baffle was used on all skids. These graphs generally outline the operating region which produces acceptable shells. The primary emphasis was placed on the maximum shell temperature. (There is also a lower shell temperature below which defects can be produced). The results obtained for Indramic and Petrolite waxes were very encouraging. Indramic wax Comp B produced no defective shell where projectile temperatures were less than 82°F and explosive less than 182°F. Petrolite wax Comp B produced several skids with defects with a shell temperature less than the 79°F. Most of the defects have an assignable cause. The one which accounts for most of the defects was that the shell was cooled with water prior to loading in an attempt to obtain the desired shell temperature. Thus there was uneven cooling and one or two shells may have been above 79°F when poured. The whole problem evolves from the fact that there were no provisions to cool shells on hot days, thus water cooling with a water hose to lower the steel temperature was utilized. Fortunately, this problem was only encountered in the early days of the testing program. The results from these tests indicate that Indramic and Petrolite Comp B can be poured satisfactorily provided the shell temperature is between 65° and 79°F. The results obtained for Castor wax were disappointing in view of preliminary data in Table III. There was an indication that a shell temperature of 70°F and an explosive temperature of 174°F to 180°F may produce acceptable casts, but there was insufficient data to substantiate this. The conclusion obtained from this data was that Castor wax is unacceptable.

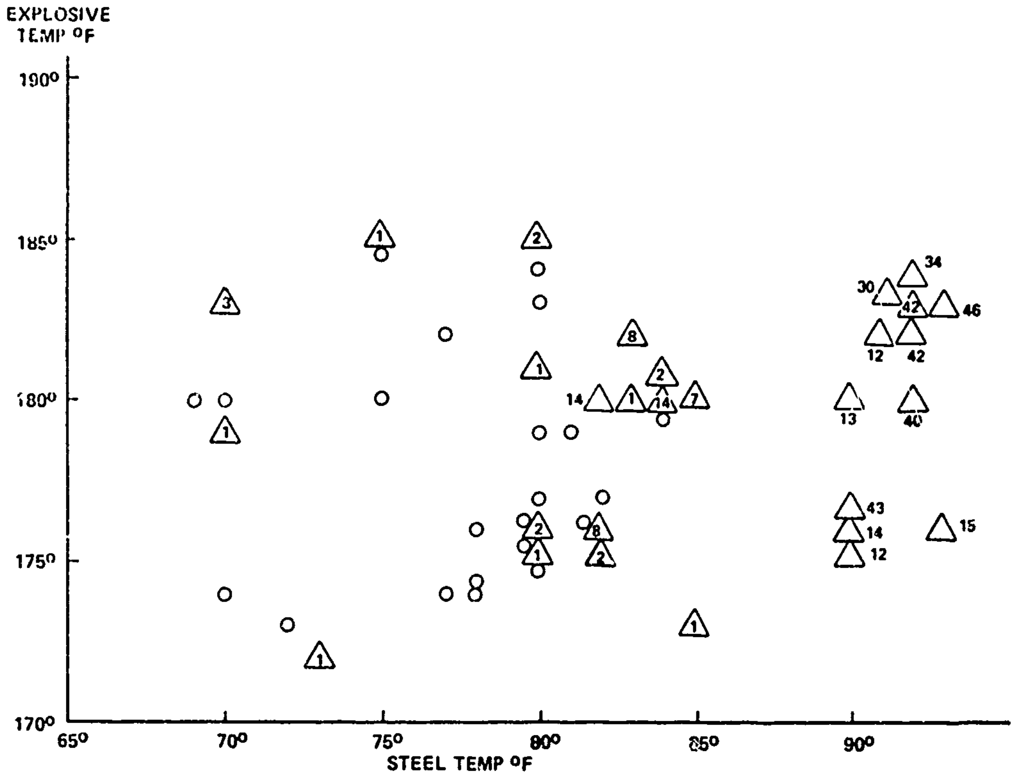


Figure 2. 105mm M1 Temperature Variable Study Comp B W/Petrolite Wax, 3120 Shell

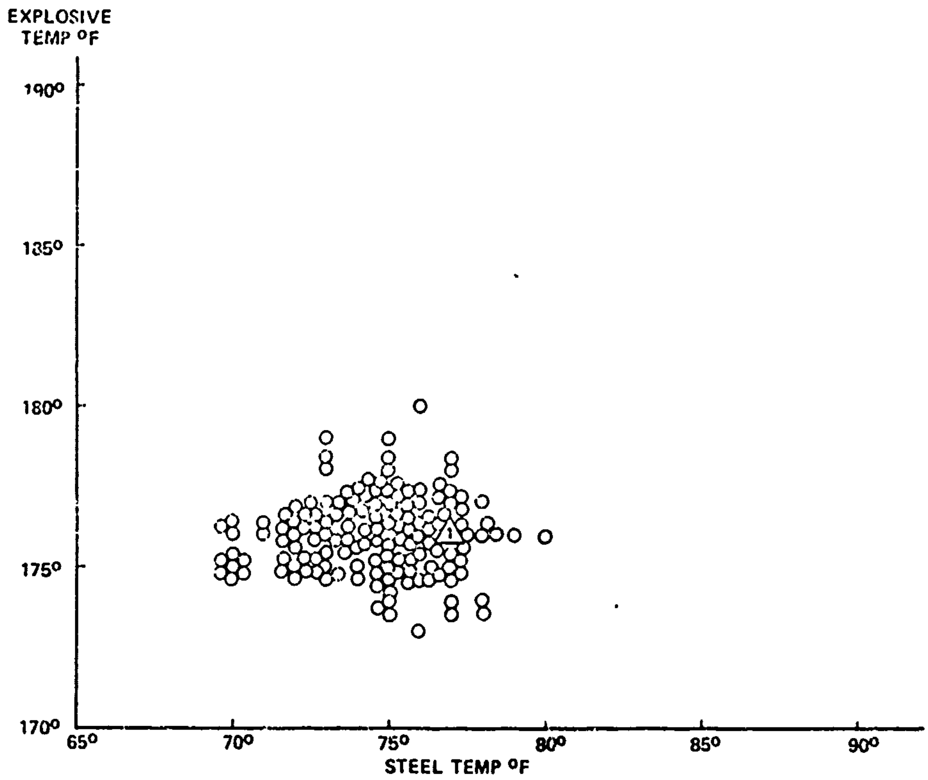


Figure 3. 105mm M1 Temperature Variable Study Comp B W/Petrolite Wax, 8880 Shell

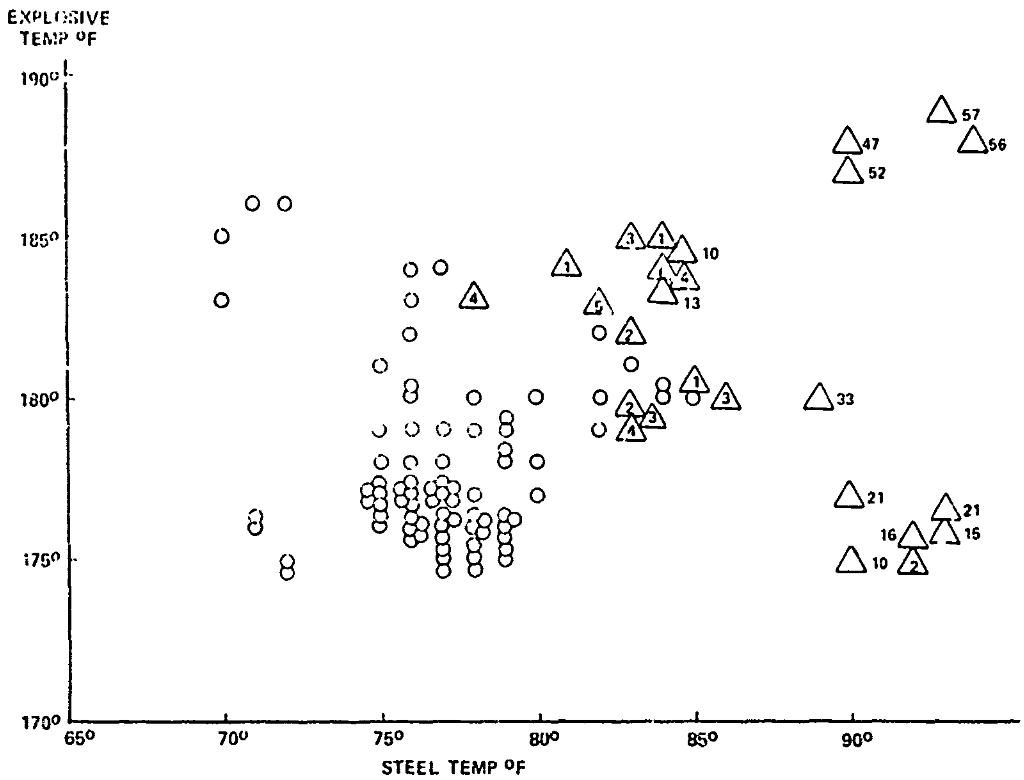


Figure 4. 105mm M1 Temperature Variable Study Comp B W/Indramic Wax, 6360 Shell

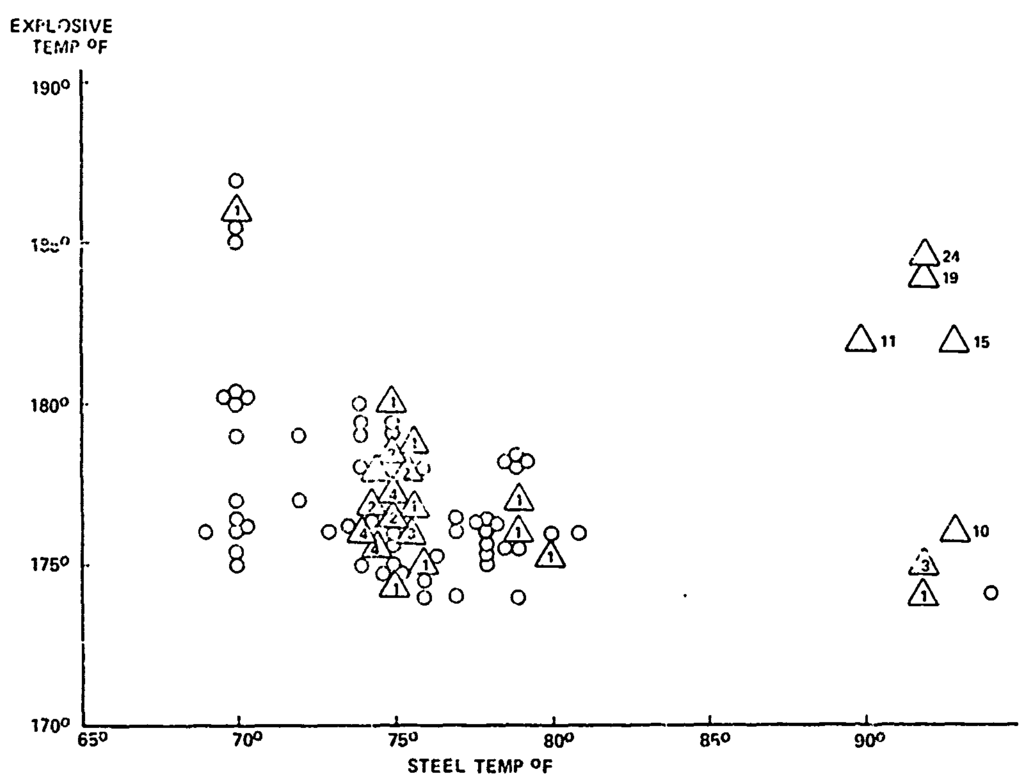


Figure 5. 105mm M1 Temperature Variable Study Comp B W/Castor Wax, 4980 Shell

2.2.3 Temperature Variables for Grade A Wax (Sunoco 8810).

A major result of this study is the emergence of data showing that the wax can have a significant, and even overriding effect in the quality of the Comp B cast. The significance is demonstrated by comparing the results of the temperature variable study of Comp B with Sunoco 8810, to the similar studies with Comp B with Petrolite or Indramic wax, discussed in 2.2.1. For example, with Sunoco 8810 only one defect occurred in a total of 8 skids (480 shells) poured, at shell temperatures of 90°F or higher, and with explosive at 179°F or higher (see Table X and Figure 6). There were no defects in a similar test with shell at 80°F and explosive at 179°F to 184°F. With Indramic or Petrolite, the combination of shell at 90°F or higher, and explosive at 179°F or higher, gives defect rates in the range of 50 to 100%. Loading the shell with Indramic or Petrolite at or near 80°F with explosive at 180°F or higher, provides a 2 to 10% defects rate. Taking shell temperature as the prime variable, the maximum for the Grade B waxes is near 80°F, while the Grade A (Sunoco) wax can tolerate shell temperatures in excess of 90°F.

TABLE X. SUMMARY OF RESULTS FOR TESTS 0-1 THRU 0-4, SUNOCO WAX VIRGIN MATERIAL

	Nominal Shell Temperature °F					
	80°F			90°F		
Nom Exp Temp °F	Number of Defects	Actual Shell Temp	Actual Exp Temp	Number of Defects	Actual Shell Temp	Actual Exp Temp
180	0	80	180	0	91	179
	0	80	180	0	90	179
	0	80	180	0	95	180
	0	80	180	0	95	180
184	0	80	182	0	94	185
	0	80	183	0	90	185
	0	81	182	1	94	185
	0	81	184	0	96	184

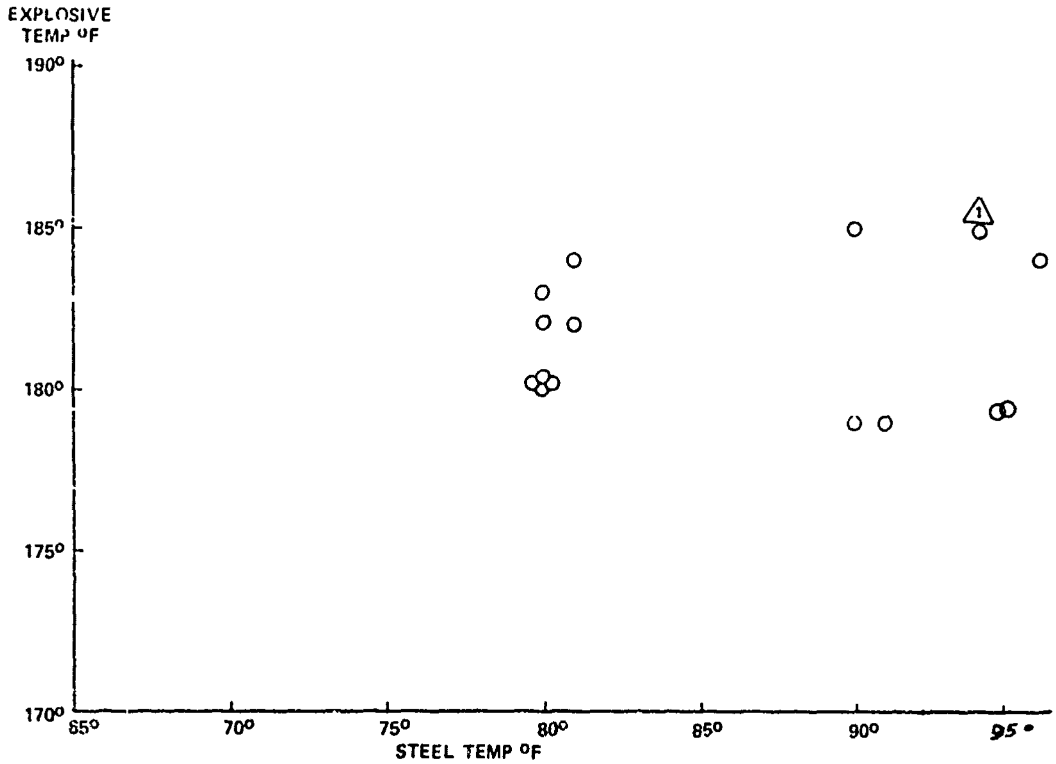


Figure 6. 105mm M1 Temperature Variable Study Comp B W/Sunoco 8810 Wax, 960 Shell

These data are confirmed with hindsight to prior production experiences. First, the Sunoco 8810 wax has been the wax used almost exclusively in Comp B for several years. There were at least five seasonal cycles where Comp B with Grade A wax was loaded in the 105mm M1 shell in summer months, without undue difficulty. While there were defects and rejects in these periods, the ratio was not such that the basic load plant production capabilities were compromised, or that the sampling plans and inspection criteria became unworkable. Summer operations at Joliet, Kansas or Lone Star AAP certainly involved use of shells at temperatures over 90°F and probably nearer to 100°F on occasion. There were other Grade A waxes also utilized, namely Witco A and Witco A/B. While not studied specifically in this effort, a review of prior production experience suggests they seemed to behave more like Sunoco 8810 than Grade B waxes in current use. In any event, they did not cause rejects to the extent that loading capabilities were compromised.

A second point regarding the influence of Sunoco 8810 is the production experience in the summer months of 1973. At both Joliet and Kansas AAP, following the initial difficulties with Petrolite and Indramic waxes, production loading was done with mixtures of Comp B with Grade A wax and Comp B with Grade B wax. The proportions ranged from 1 part Grade A with 1 part Grade B, up to 1 part Grade A with 3 parts Grade B. Mixing

was done at the time, to extend the available supplies of Grade A wax. The results of mixing were satisfactory; as evidenced by the fact that no undue problems occurred in maintaining required cast quality confirmed by radiographic inspection.

Thus, it seems that the Sunoco 8810 wax contains an ingredient which acts as a casting aid, and which significantly broadens the range of temperatures for both the metal parts and the explosive, to yield an acceptable cast. Further, it seems that only a small amount of this ingredient is necessary from the mixing experiences. This is consistent with Picatinny Arsenal laboratory data showing that waxes are soluble in TNT to a very limited extent -- less than 0.1%. Therefore, the fraction or element which is soluble, and identifying the effect it can have on crystallization of TNT may be the key to a better understanding of the shell loading process. This aspect is being followed up by Picatinny Arsenal and others. Attention has focused on hexanitrostilbene (HNS), known from literature to be a nucleating agent for TNT, on Biphenyl which like HNS is a double ring compound (Biphenyl is known to be in Sunoco 8810), and on other double cyclic compounds which are known to exist in continuous process TNT.

2.3 EFFECT OF SPAN 85.

Span 85, a surfactant, has been used (optionally) in the production of Comp A3 and other RDX/wax systems, where it was desirable to maximize the degree of wax to crystal contact, and to have a uniform distribution of wax. With the observations of the greater tendency for Grade B waxes to segregate in Comp B, the same agent was evaluated. There were reasons to think the cast quality problems were related to the segregation of the wax.

In an attempt to prevent the separation of the wax from the explosive, 0.1 percent Span 85 was added. Two waxes with Span 85 were tested, Indramic and Petrolite. Figures 7 and 8 show the results of these tests. The results for Indramic wax show no improvement at 85°F shell temperature. The results for Petrolite wax were worse. Defects were found on skids with shell temperatures less than 79°F. In this case, the addition of Span 85 was apparently detrimental to the process under study. Observations made during the tests indicated that there was no decrease in the amount of wax separation in the melt kettles, or on the top of the risers in the case of Indramic wax. In conclusion, Span 85 does not significantly aid in the production of acceptable 105mm shells.

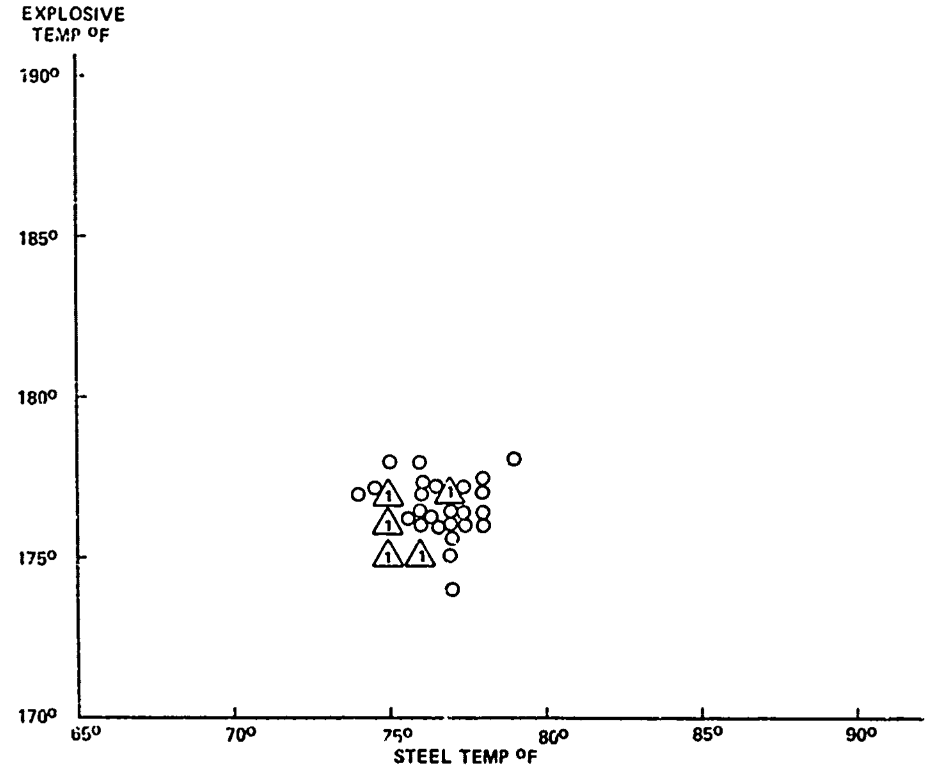


Figure 7. 105mm M1 Temperature Variable Study Comp B W/Petrolite Wax W/.1% Span 85, 1800 Shell

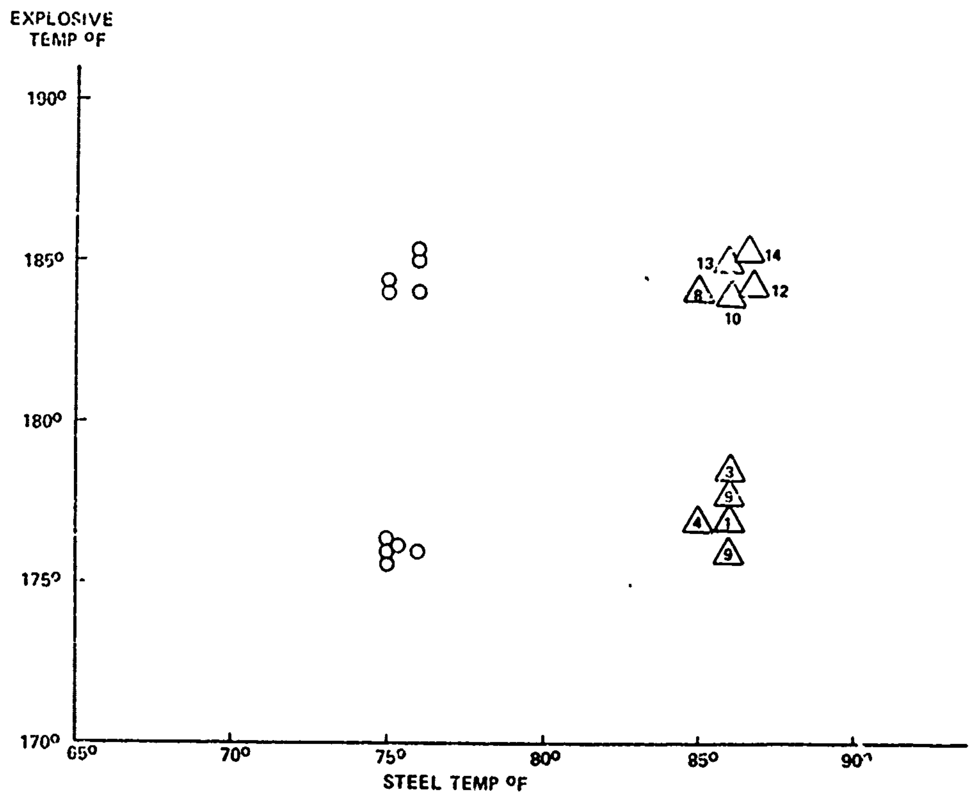


Figure 8. 105mm M1 Temperature Variable Study Comp B W/Indramic Wax W/.1% Span 85, 960 Shell

2.4 HOT TOP-OFF.

The purpose of the riser portion of the riser-former used in conjunction with cast loading is to provide a reservoir of heat and molten explosive to fill voids created by the shrinkage of the solidifying explosive. However, if the neck of the riser freezes before the charge in the central portion of the shell solidifies, a void or a porous charge could result. In the present 105mm M1 shell design with the metal riser-former design, the rate of heat loss is lowest in a central area about 6 to 9 inches below the nose of the shell. Solidification of the cast occurs from the bottom up, side walls in, and top down leaving an isolated molten interior about 6 to 9 inches below the nose of the shell. Solidification occurs in the neck of the riser-former (adjacent to the middle of the shell threads) within about thirty (30) minutes of casting, whereas the central portion of the shell solidifies within about 1 to 1-3/4 hours.

Hot top-off was a proposed solution to prevent formation of cavities. The idea was to put additional heat into the riser, and thus prolong the time before the explosive in the former section of the riser solidified. The procedure was to pour the bulk of the explosive at the normal pour temperature. Two different pour heights were tried (see Figure 9):

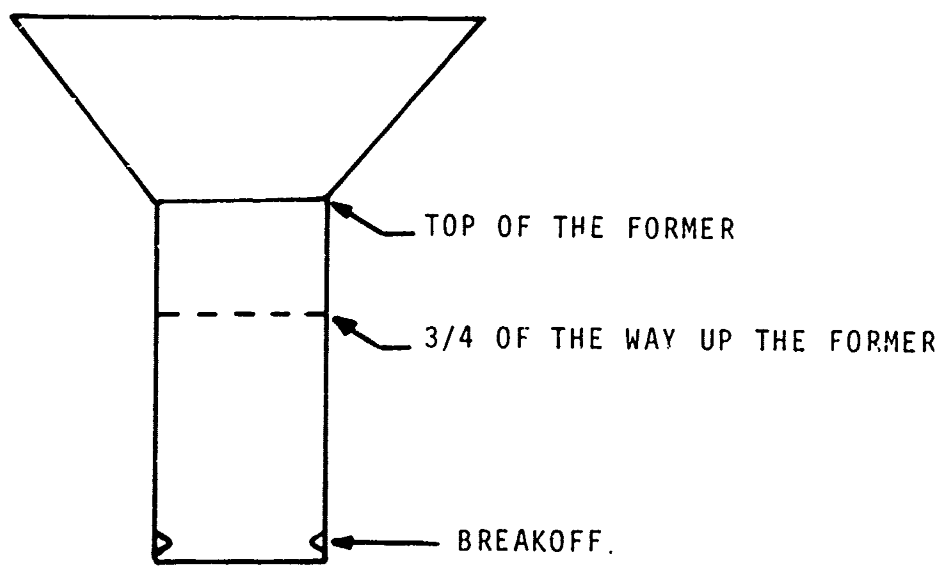


Figure 9. Pour Heights of Initial Pour in the Riser for Hot Top-Off

The skid was then moved to a second multipour where the remainder of the explosive was poured. The top-off temperature was 200°F, versus the 176° or 184°F for the explosive temperature in the initial pour. The explosive was Composition B manufactured with Petrolite wax and sorted to a viscosity of 5 seconds or less. The results of these tests are shown in Table XI. The results do not show that allowable shell temperature can be higher than that for the simple single pour process. This process would be difficult to implement due to the two separate pouring operations.

TABLE XI. RESULTS OF HOT TOP-OFF TESTS

Height of First Pour	Shell Temperature	Explosive Temperature First Pour	Explosive Temperature Top-Off	Defects
Top of former	84	178	194	2
Top of former	84	177	195	1
Top of former	82	176	198	0
Top of former	80	176	198	1
Top of former	80	185	198	0
Top of former	80	184	198	0
Top of former	80	184	192	0
Top of former	80	183	193	0
3/4 way up former	80	178	198	1*
3/4 way up former	80	184	194	0
3/4 way up former	80	178	194	0
3/4 way up former	80	178	194	0

*Most of the shells on this skid were poured too low to produce an acceptable cast.

TABLE XI (Continued)

Height of First Pour	Shell Temperature	Explosive Temperature First Pour	Explosive Temperature Top-Off	Defects
3/4 way up former	80	184	-	0
3/4 way up former	82	184	200	0
3/4 way up former	-	184	200	0
3/4 way up former	82	184	200	0

The explosive was Composition B manufactured with Petrolite wax and sorted to a viscosity of 5 seconds or less.

2.5 PROBING.

Probing was proposed as another method to introduce additional heat into the riser. The theory was that additional heat added after the explosive was poured into the shell would increase the time delay before the explosive solidified in the neck of the riser. Probe depths from 1 inch to 4 inches above the break-off point, and dwell time of 5 seconds to 15 minutes were tried. Details are in Appendix D, Test Groups C, D, E, J and K. A broad summary of results is shown in Figures 10 and 11, for Petrolite and Indramic waxes. These figures combine the data for all conditions of probe depth and time. The results do not show any advantages derived from probing. The technique of probing does not overcome the detrimental effect of a hot projectile. The defects when steel temperature was below 80°F may be attributed to the fact that the probe mechanism may have come in contact with the riser, thus adding heat to the shell center in addition to the riser (see Figure 12). The conclusion was that probing will not help prevent the formation of cavities. It was also demonstrated that probing introduced other operational difficulties and made the loading process more complicated.

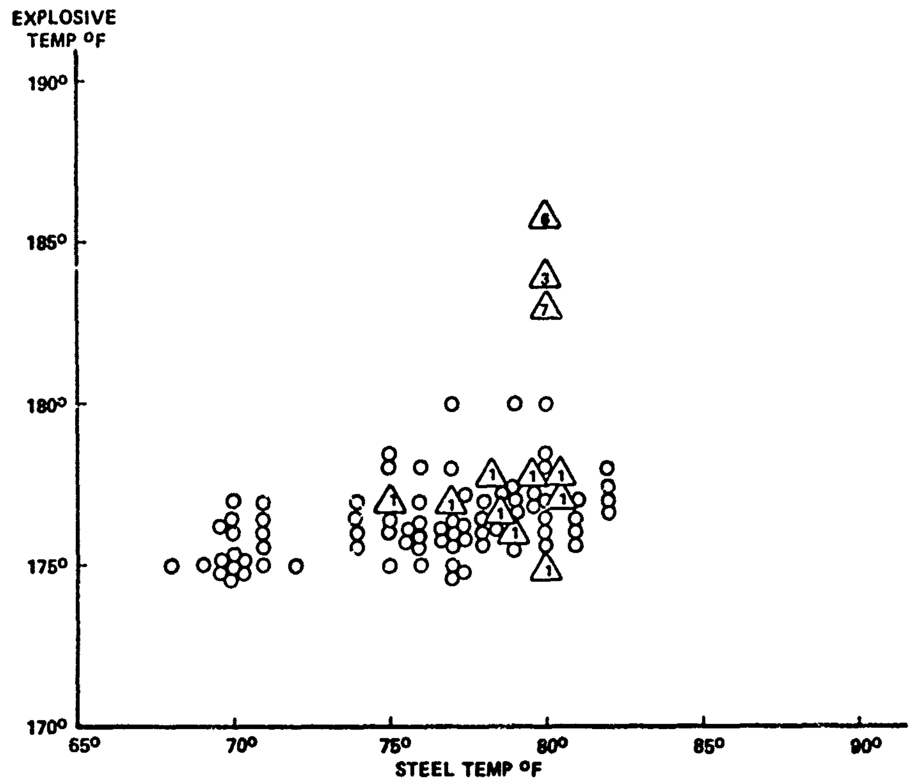


Figure 10. Probing Temperature Variable Study For Loading 105mm M1 With Comp B, With Petrolite Wax, 5340 Shell

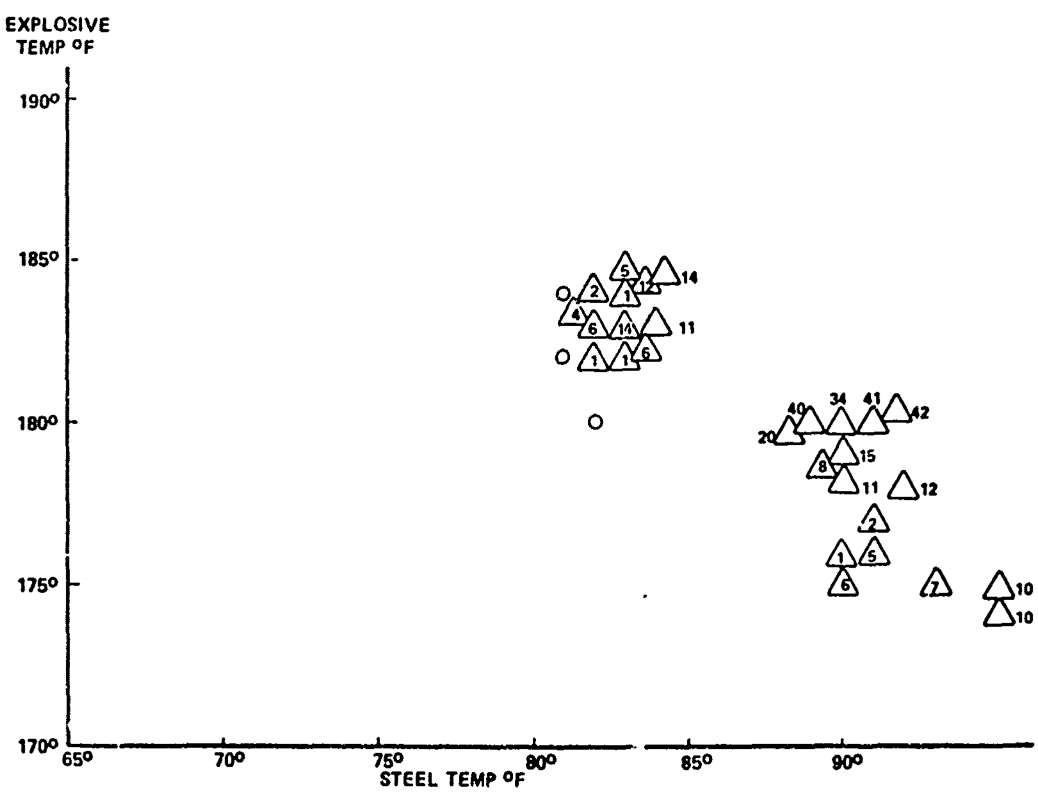


Figure 11. Probing Temperature Variable Study For Loading 105mm M1 With Comp B, With Indramic Wax, 1920 Shell

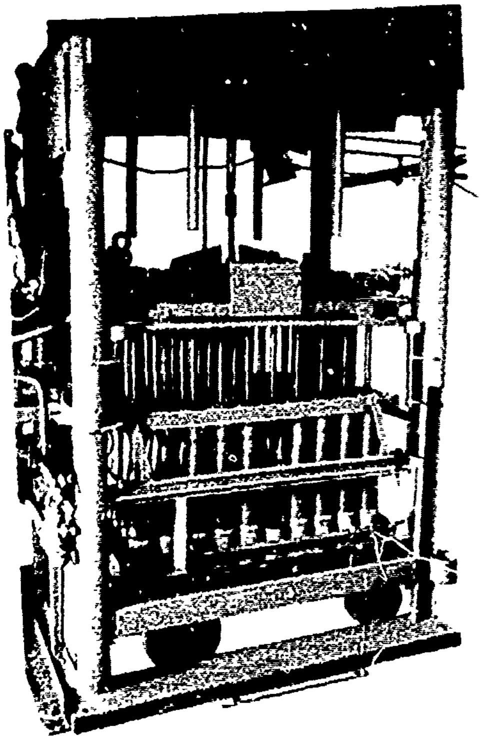


Figure 12. Probing a Skid (Note the Probe in Contact With the Riser in the Center of the Skid)

2.6 HOT TOP-OFF AND PROBING.

There were three sets of tests performed to determine if a combination of a hot top-off and probing could produce acceptable casts. The procedure was to pour the bulk of the explosive at 176 ± 2°F. The pour height was three quarters the way up the former, (see Figure 9). The skid was then transported to a second multipour where the remainder of the explosive was poured at 195° to 200°F. The skid was then moved to a probe machine, probed for the time period shown in Table XII, and then placed in a cooling bay. Between the second pour and probing, the skid was covered with a shroud. The results from these tests are presented in Table XII. The occurrence of defects using projectiles at or near 80°F shows no improvement over the simple single pour process. These data and the obvious production complications were the bases for discontinuing this approach.

TABLE XII. RESULTS OF HOT TOP-OFF AND PROBING TESTS

Probe Time	Shell Temperature	Explosive Temperature First Pour	Explosive Temperature Top-Off	Defects
15 Seconds	80	176	195	1
	80	177	195	0
	80	177	195	0
	80	178	198	0
2.5 Minutes	80	177	197	1
	80	177	197	1
	81	177	195	0
	-	178	191	0
5 Minutes	81	176	202	0
	81	176	200	0
	81	176	199	0
	81	177	200	0

The explosive was Composition B manufactured with Petrolite wax with a viscosity of 5 seconds or less.

2.7 SPLIT POURING.

The purpose of split pouring was to allow the lower portion of the explosive cast a lead time to start solidifying, before the remainder of the explosive was poured into the shell. The procedure was to pour approximately 50% of the explosive into the shell, then allow a 1 to 3 minute delay before the remainder of the explosive is poured. The skid was cooled in the usual manner. The results of these tests are shown in Table XIII. From these results it is apparent that split pouring does not provide any significant improvement to the process when the steel shell temperature is above 79°F.

TABLE XIII. SPLIT POURING

Indramic - Double Pour

40% Scrap

Steel 90° ± 2°

Expl 180° ± 2°

50% Explosive Charge Increments

No. Shell	Pour Delay	Defects Crit.	Defects Minor
180	1 Min	34	22 (1)
180	2 Min	55	48
180	3 Min	40	65
120 (2)	Straight Pour	12	33

(1) Includes one defect free skid

(2) Includes last skid from low reservoir

Prior to these tests an extra skid was poured in two increments. Table XIV provides the process data. The initial pour consisted of approximately 50% of the total. After a 3 minute delay, the remainder of the explosive was poured. All of the shells were X-rayed and found to be acceptable. Upon sawing a shell in half and examining the explosive cast, an annular ring was noted. Figure 13 shows the explosive cast typically found from all split poured shells. From this skid it was concluded that split pouring may cause more problems than it solves.

TABLE XIV. DATA ON SPECIAL SPLIT POURED SKID

Date:	9-20-73
Explosive:	Composition B Manufactured With Petrolite Wax Sorted High Viscosity
Shell Temperature:	75°F
Explosive Temperature:	176°F
Average Cooling Bay Temperature:	83°F
Shroud Time:	75 minutes
First Pour:	Approximately 40% of total volume
Time Delay Between Pours:	3 minutes
X-Ray Results	*No defects were found

*Annular ring discovered upon sawing shell.

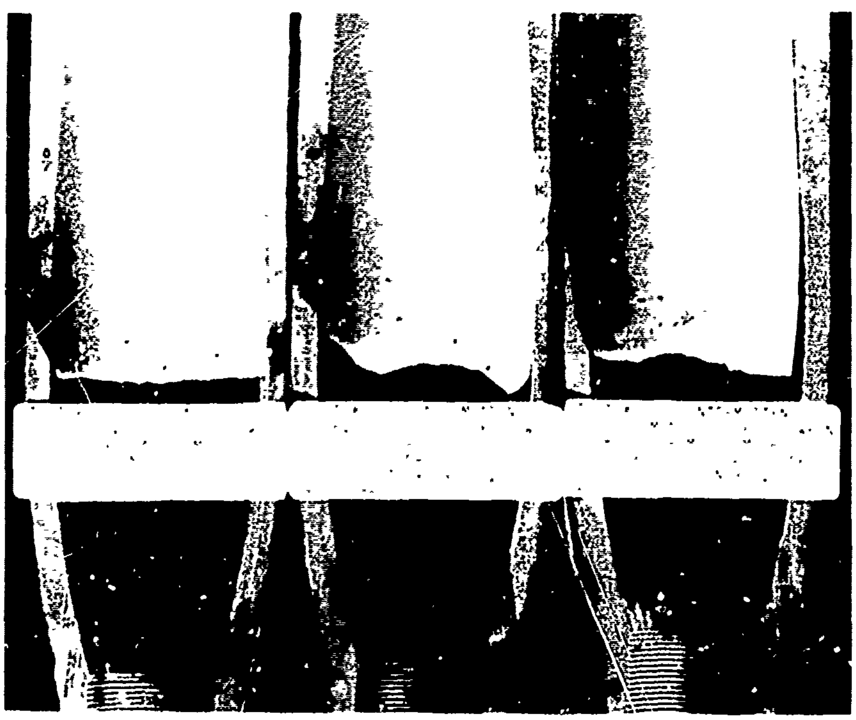


Figure 13. Annular Ring Defect, Split Pouring Test

2.8 WATER COOLING TEST.

2.8.1 General.

The primary purpose of water cooling tests was to increase the rate of heat removal from the base of the shell, thus increasing the rate of solidification of the explosive in the bottom section of the shell. The expected end result, when using water cooling, was to have a smaller mass of molten explosive in the center of the cast when the explosive in the neck of the riser solidified. After the neck of the riser is blocked by cast solidification, any additional shrinkage which takes place will result in either a low density volume of explosive, or a cavity, depending on the amount of shrinkage. Using this process, it was anticipated that "hot" shells (79-95°F) could be loaded satisfactorily with Comp B with Grade B wax. A reasonable expected side benefit for this process is a decrease in the cooling period for the shells.

2.8.2 Water Jacket Construction.

To permit water cooling, a skid rack was placed inside a water jacket which was equipped with an inlet and four outlets (see Figures 14 and 15). The inlet was located between shell positions 6 and 12. The outlets were located bewteen shell positions 43-47 and 49-55 at 1/2, 1-1/2, 3-1/2 and 5-1/2 inches from the bottom of the water jacket. The sides of the water jacket were 6 inches high.

2.8.3 Test Procedure.

Prior to pouring, the appropriate outlet nozzle was opened and the water flow adjusted to a predetermined flow rate. The explosive was then poured into the shells and the skid transported to its cooling location. The inlet and outlet hoses were connected to the water jacket. The water flow, if any, after the prescribed depth was obtained, was maintained until the shroud was removed (75 minutes after pouring). Immediately after the shroud was removed, the water flow was terminated and the water jacket drained. See Table XV for tests summary.

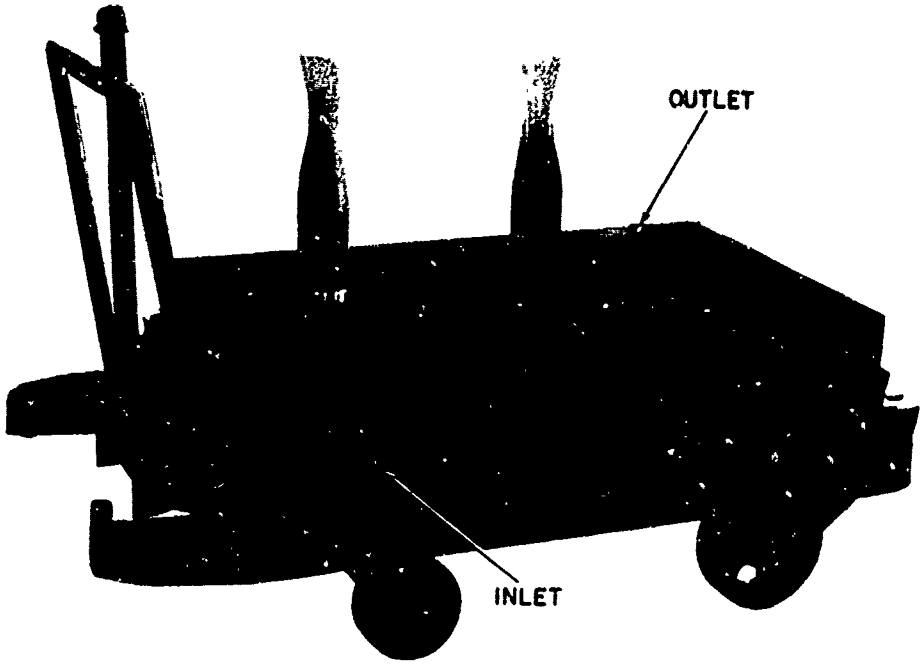


Figure 14. Water Cooled Skid

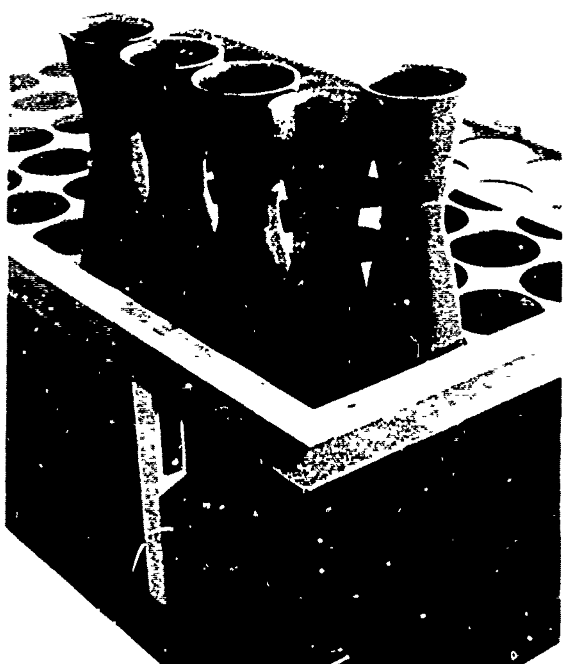


Figure 15. Close Up of Water Jacket

TABLE XV. WATER COOLING TEST

	W1	W2	W3	W4	W5
Date	10/9/73	10/11/73	10/11/73	10/15/73	10/16/73
Skid	7	12	12	18	20
Rsvr Temp (°F)	184	182	190	186	182
Cup Temp (°F)	181	180	178	184	180
Matl Temp (°F)	179	180	179	185	187
Shell Temp (°F)	89	88	87	93	93
Duration of Pour (sec)	45	43	98	35	47
Multipour No.	2	2	2	2	2
Lot HOL-	053-5030	053-5030	053-5030	053-2150	053-5095
Wax Type	B	B	B	A	B
Washers	No	No	Yes	Yes	Yes
Water Hgt (inches)	3.5	3.5	6.0	6.0	6.0
Flow Rate (gpm)	0	2.5	2.2	2.3	0
Inlet Temp (°F)	70	68	65	65	76
Cooling Bay	Sump	Sump	Sump	Sump	7
Shells Poured	60	60	60	60	60
Criticals	6	2	0	38	2
Minors	13	3	0	17	1
Cavities	19	5	0	55	3
Good Shells	41	55	60	0	57

2.8.3.1 Test W-1. There was a 5°F difference between the water temperature near the inlet and outlets 11 minutes after the skid was poured, with a water depth of 3.5 inches and no flow. Cavities developed in 19 shells (see Figure 16).

2.8.3.2 Test W-2. Under flow conditions of 2.5 gpm, and a water depth of 3.5 inches, there was a 17°F water temperature difference between the inlet and outlets 12 minutes after the skid was poured. There was also a difference of 2° and 10° in the water temperature near the bottom versus the top of the water bath. Cavities developed in 15 shells (see Figure 17). As a result, shell position becomes important, because some shells will receive more or less cooling depending upon their location on the skid.

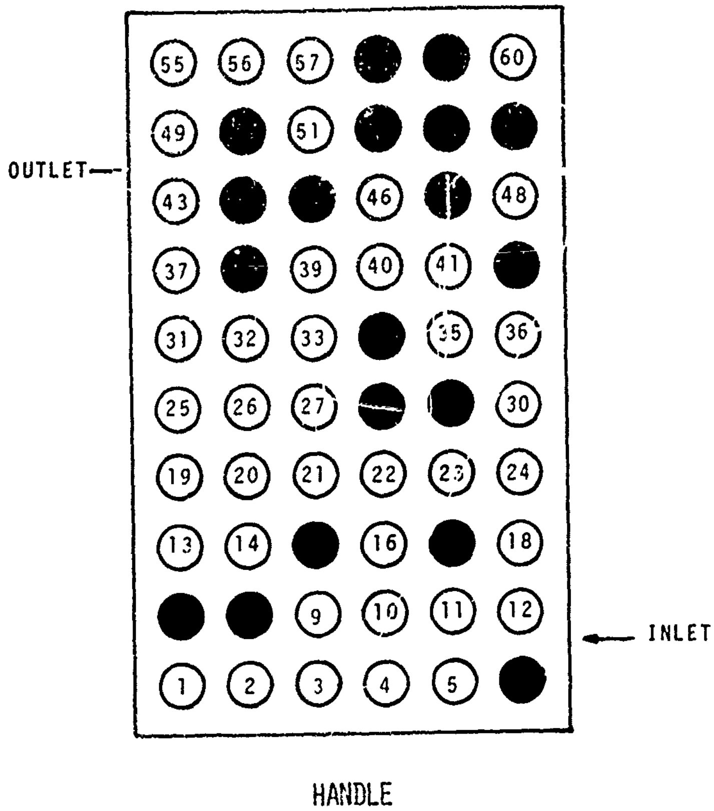


Figure 16. Test W-1, Location of Defects Caused by Cavities

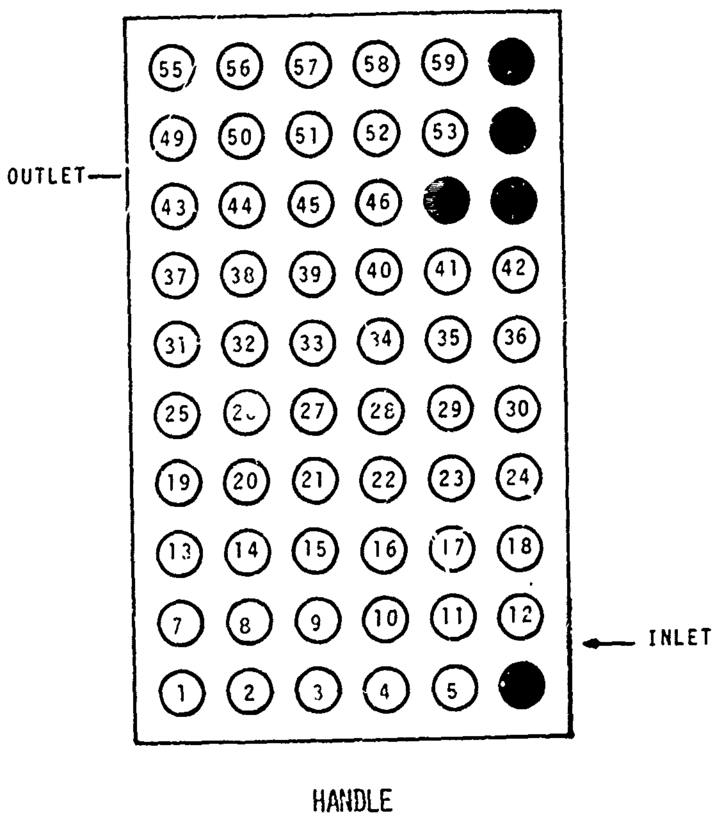
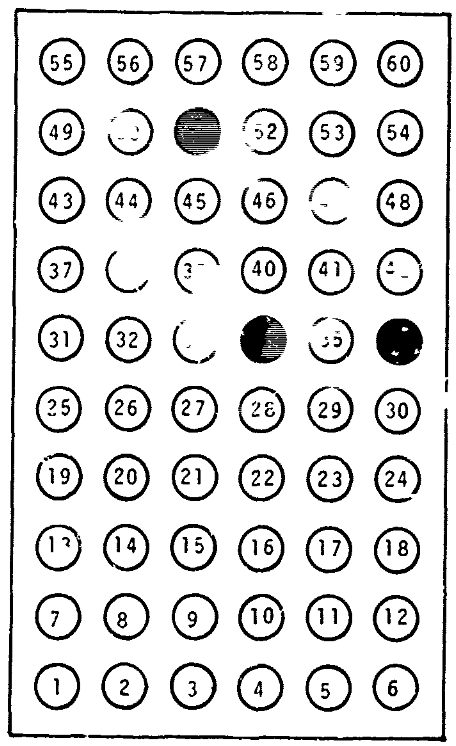


Figure 17. Test W-2, Location of Defects Caused by Cavities

2.8.3.3 Test W-3. Of the five skids poured, only one (Test W3) appeared to be defect-free from X-ray results. Upon sectioning one of the shells, extensive cracking was observed in the cast. This was a different type of defect not previously observed and not detectable with the existing X-ray equipment. Upon this discovery, the additional shells on this skid were considered rejects and steamed out for reuse.

2.8.3.4 Test W-4. The results for Test W4 were equally disappointing due to a large number of shells which had cracks in the "A" segment on the X-rays, and the almost total lack of shells which did not have any voids in the "C" segment. The most significant fact was that Grade A Comp B was used. Using 93°F shell temperature, no defects were expected to be found in this skid. Cavities developed in 55 shells (see Figure 18).



(SOLID INDICATES GOOD SHELLS)

HANDLE

Figure 18. Test W-4, Location of Defects Caused by Cavities (Not Including Cracks)

2.8.3.5 Test W-5. Results of Test W5 at a water height of 6 inches, and a no flow condition are shown in Figure 19.

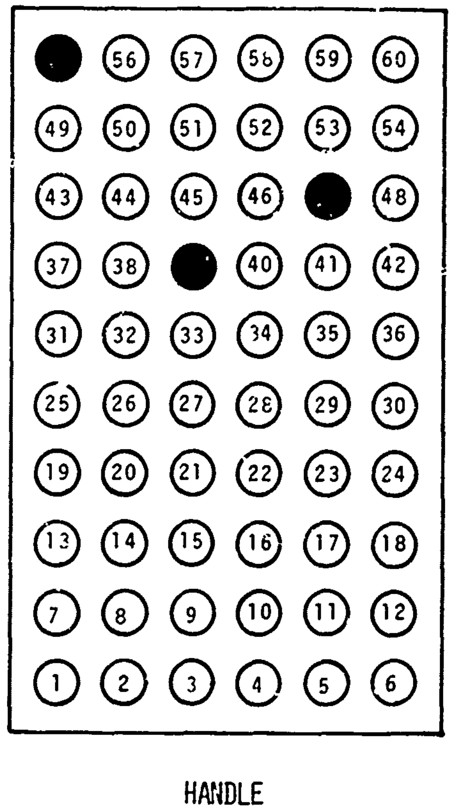


Figure 19. Test W-5, Location of Defects Caused by Cavities

2.8.4 On the last three water cooled skids fiber washers were inserted between the riser and the shell to determine if partially insulating the riser from the shell would leave any effect on cavity formation. Theory was that by partially isolating the riser from the shell, there would be less heat transfer from the riser to the shell, and thus a decrease in the solidification rate of the explosive in the neck of the riser. Refer to the discussion on fiber washers 2.12. The results of tests with fiber washers were also disappointing.

Although the results were disappointing, the authors feel more work should be performed before totally discarding water cooling. Much was learned from these few tests about water cooling. The major disadvantage to the described apparatus was the poor flow pattern. Temperature gradients were observed throughout the skid. These gradients were more pronounced during the start of the cooling period. This process was not found to be a simple process by which cooling shells could be speeded without careful consideration as a major process variable which may have to be precisely controlled. If future consideration is given to water cooling, a detailed process study must be undertaken correlating the effects of water temperature, flow rate, flow pattern, depth, initial steel and explosive temperature, etc. Careful consideration must be given to the cracking problem which was not detectable by existing X-ray equipment.

2.9 SHROUD DESIGN STUDY.

Canvas shrouding of the skid has been a long time practice after melt loading of 105mm shells, (see Figure 20). Prior to the start of this project, the Ad hoc Committee decided to design and test a more efficient shroud to replace the long used canvas shroud. The design consisted of an insulated wood shroud, and baffle. The purpose of this design was to decrease the rate of heat transfer from the enclosed metal parts, thus maximizing the opportunity for explosive mass flow from the riser to the shell center. This it was thought would be accomplished firstly by maintaining the maximum possible air temperature, and secondly to provide a uniform air temperature around the top of the shell. Figures 21 and 22 show a skid with the wood shroud and baffle. The wood shroud was designed so that there was no contact between the risers and the shroud; this was necessary to prevent any concentricity problems in the fuze well.

During testing which was performed to determine effect of shroud design, additional data was obtained regarding air temperature around the risers. This data was in form of air temperatures around the risers versus time after pouring of the shells. Data was obtained for the following shroud designs:

1. Canvas shroud
2. Wood shroud without baffle
3. Wood shroud with baffle

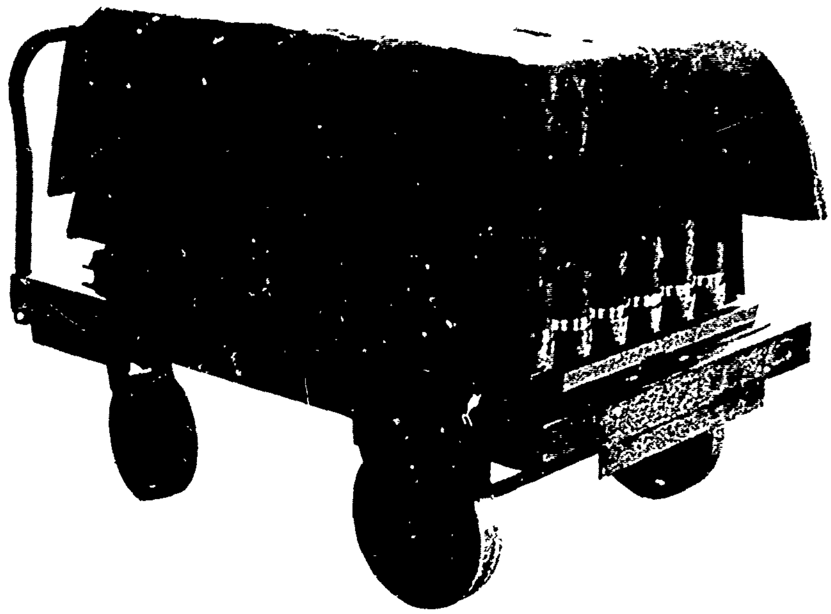


Figure 20. Skid Covered With a Canvas Shroud

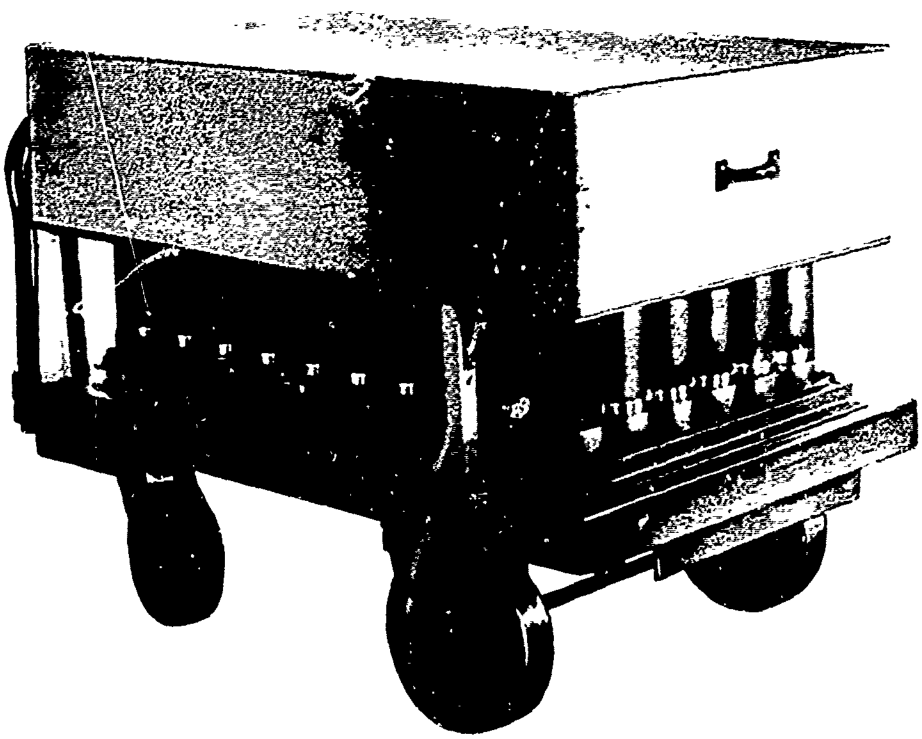


Figure 21. Skid Covered With Insulated Wood Shroud

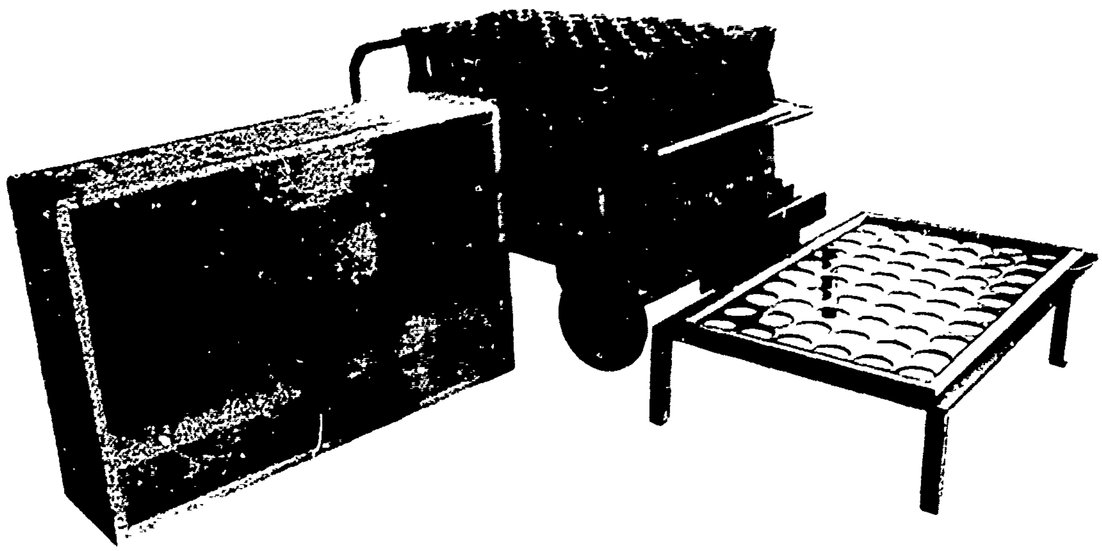


Figure 22. Skid With Wooden Shroud Components

In some cases, the steel temperature of the shell was also obtained at one or two locations of the shell below the baffle. Test conditions are shown in Table XVI, the resulting curves are shown in Figures 23 through 26. The horizontal axis is time in minutes after the skid was poured. The vertical axis is degrees Fahrenheit. The air temperature around the risers in the center of the skid are represented by circles (⊙). A square (⊡) represents the outside temperature of the shell at a point 6.5 inches from the base, and a diamond (◇) represents the outside temperature of the shell immediately above the rotating band. The peak air temperature was usually reached 22 to 24 minutes after pouring. The maximum air temperature for various shroud designs are shown in Table XVII.

TABLE XVI. SHROUD TEST CONDITIONS

Figure Number	23	24	25	26
Shell Temperature	80	77	80	79
Explosive Temperature	180	177	175	176
Wax in Composition B	Sunoco	Petrolite	Petrolite	Petrolite
Test Group	0	Q	Q	Q
Test Number	1	Special	5	4
Skid	2	21	15	1
Date	10/15	10/23	10/23	10/23

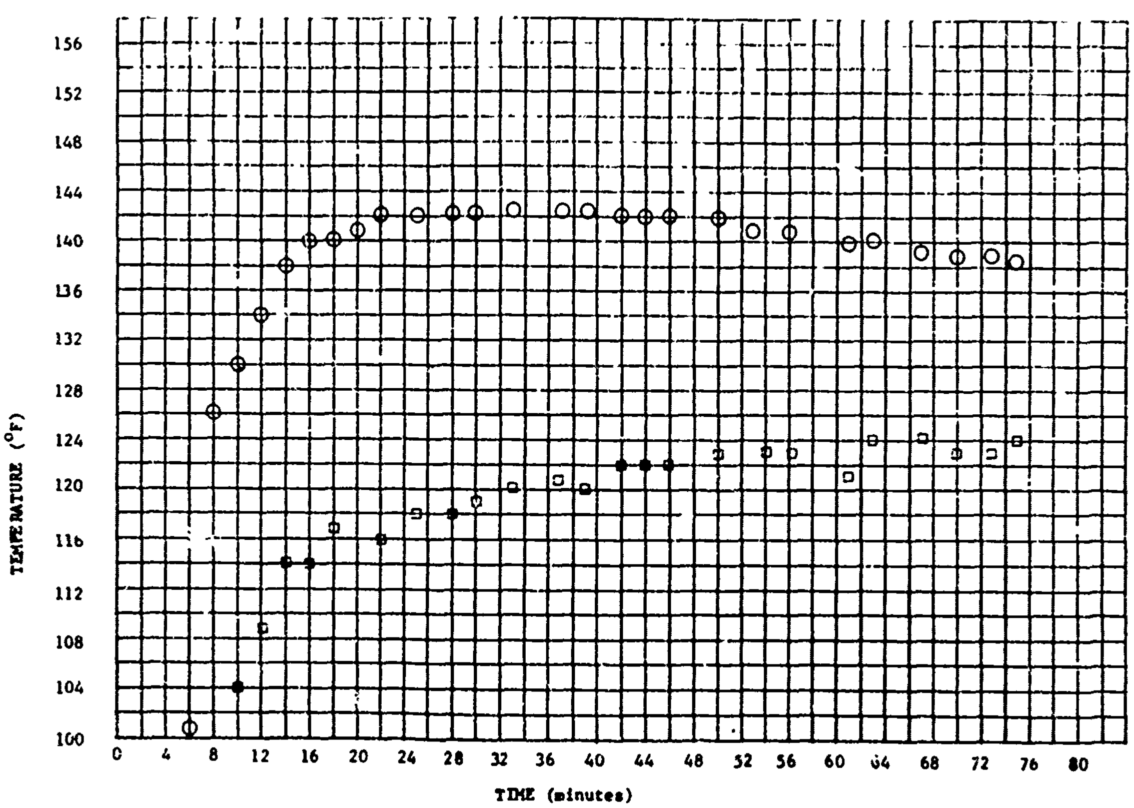


Figure 23. Air Temperature Under Wood Shroud With Baffle Versus Time Curve (Sunoco Wax)

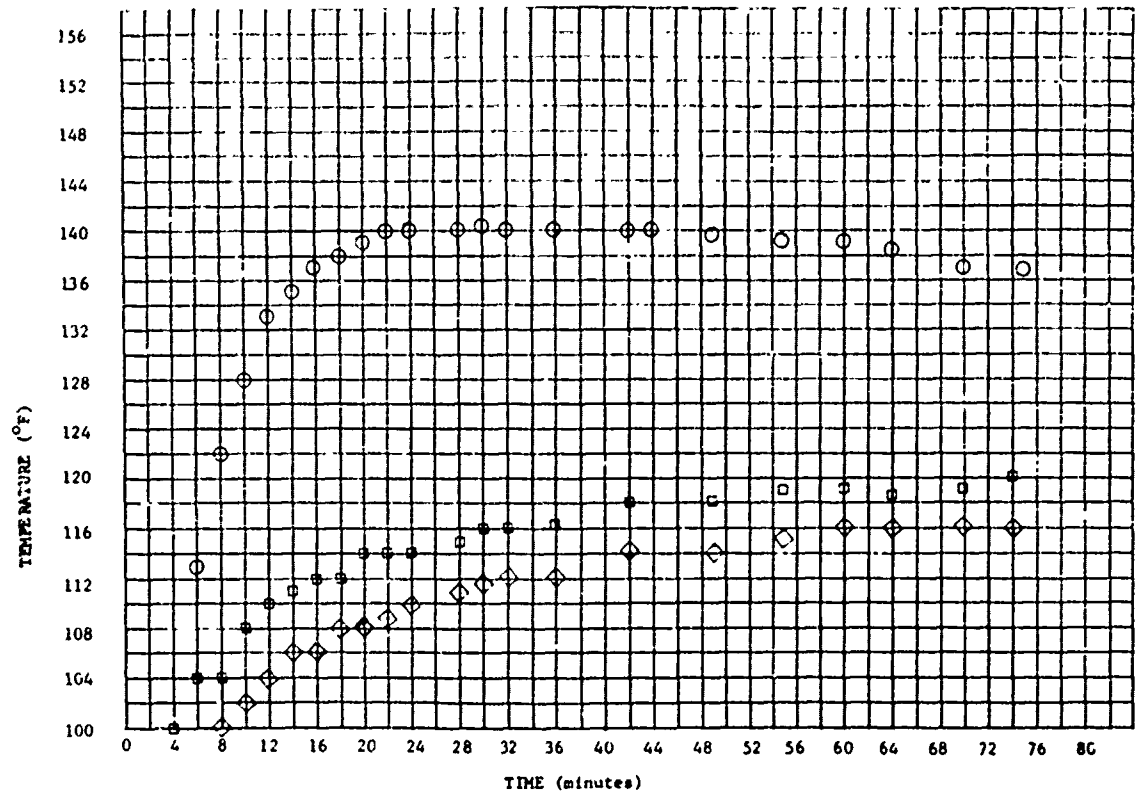


Figure 24. Air Temperature Under Wood Shroud With Baffle Versus Time Curve (Petrolite Wax)

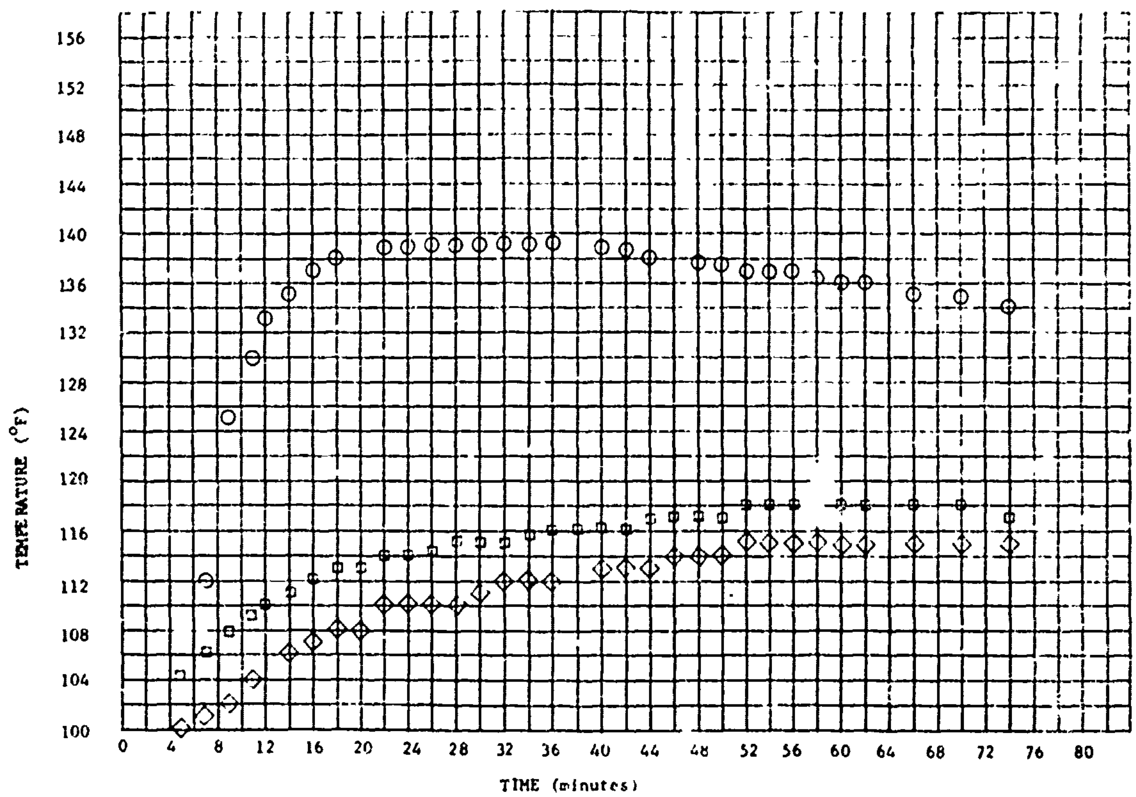


Figure 25. Air Temperature Under Wood Shroud Without Baffle Versus Time Curve (Petrolite Wax)

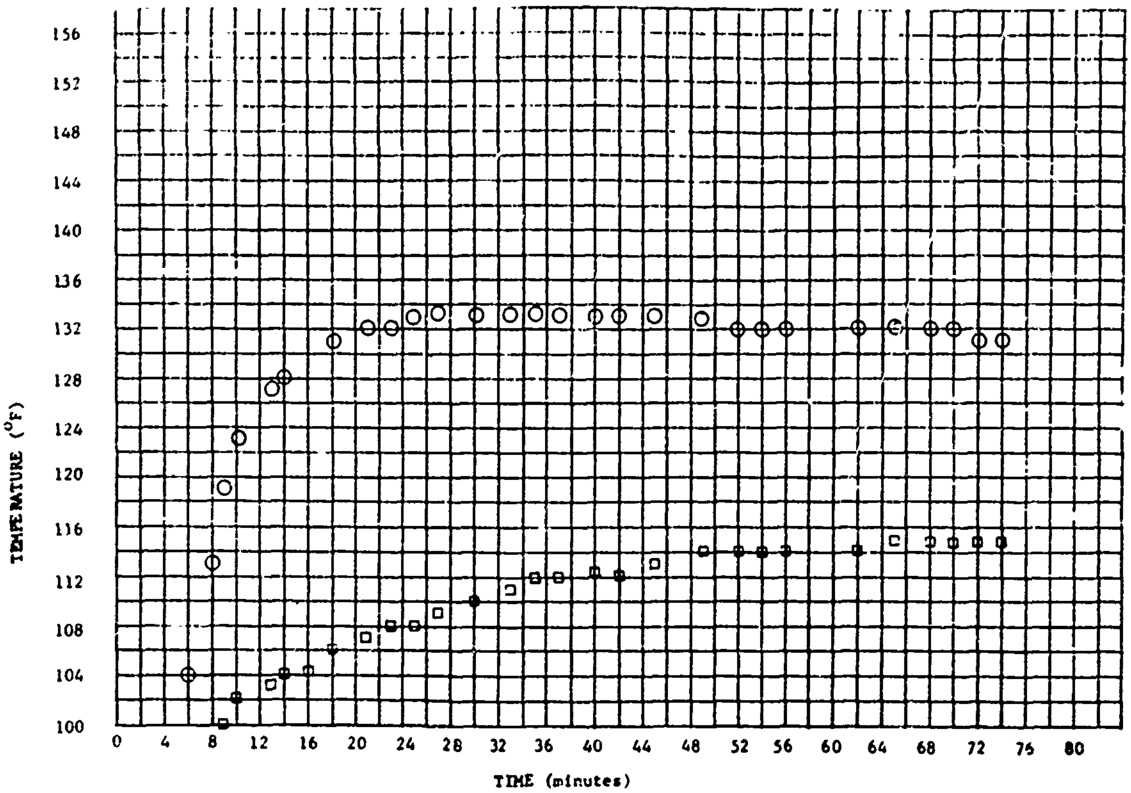


Figure 26. Air Temperature Under Canvas Shroud Versus Time Curve (Petrolite Wax)

TABLE XVII. SHROUD MAXIMUM TEMPERATURES

Shroud Design	Shell Temperature Before Pouring	Explosive Temperature Immediately After Pouring	Maximum Air Temperature
Wood Shroud With Baffle	77 80	177 180	140 142
Wood Shroud	80	175	139
Canvas Shroud	79	176	133

The data presented in Table XVII was obtained from Figures 23 through 26. The air temperature under the shroud is also affected by the shell temperature before pouring, and the explosive temperature at time the shell was poured. Thus for a fair comparison, the shell and explosive temperatures should be identical. The conclusion from these tests was that the insulated shroud maintains a higher air temperature.

One series of tests was performed to study the effect of shroud design and cooling bay temperature. The tests were designed so both variables could be studied together. Thus it would be possible to determine if one would affect the other. Table XVIII results show that the wood shroud with baffle produces fewer defects, while the canvas shroud produced the most defects per skid. The reader should keep in mind that these results are from a relatively small number of skids.

TABLE XVIII. SHROUD COMPARISON

	Canvas Shroud	Wood Shroud Without Baffle	Wood Shroud With Baffle
Shell Temp (°F)	85-86	85-86	85-86
Explosive Temp (°F)	180-181	180-181	180-181
Number of Skids	8	16	6
No. of Defect Free Skids	5	10	4
Total No. of Defects	7	13	4
Percent Good Skids	62.5	62.5	66.6
Defects Per Skid	0.875	0.812	0.666
Median No. of Defects	2	1	1-2

It was the opinion of the authors that the wood shroud with baffle produced slightly better results than the canvas shroud under non-ideal conditions. The amount (degree) of improvement was not as significant as originally anticipated, and under ideal conditions in production it may not be worth consideration. However, the wood shroud with baffle does tend to give uniform conditions less subject to extraneous variables such as cooling bay temperature, air movement, or proper placement on the skid. The canvas shroud is subject to variations from each of these conditions. Therefore, the use of wood shroud and baffle or an equally efficient shroud is recommended even though the improvement with respect to defect rate is not statistically significant.

2.10 SHELL POSITION ANALYSIS.

In previous work done by Mr. B.A. Kavanaugh of Joliet AAP, there was some indication that shell location on skid may be a significant factor affecting the production of defective shells. In Mr. B.A. Kavanaugh's analysis, each shell was placed in one of three groups, outside, middle, or center ring. Figure 27 shows the group location on a skid card. The results from Mr. Kavanaugh's first two studies are shown in Table XIX, along with the results of this study. These studies represent unspecified total sample populations but always represent similar skids with 60 identical positions.

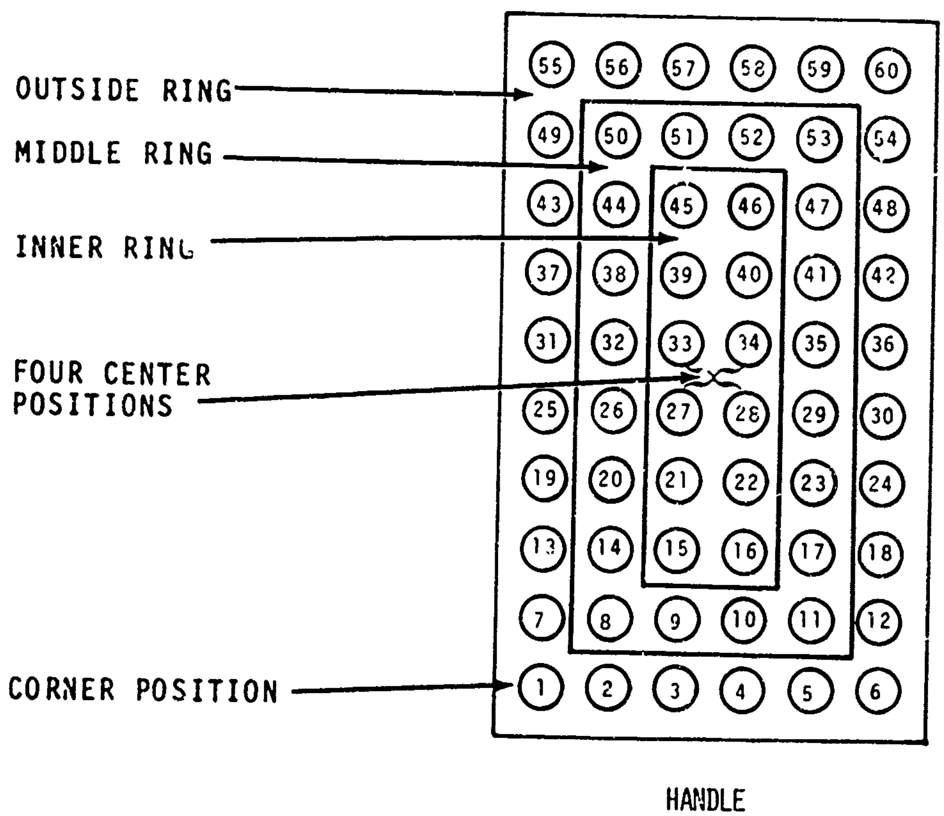


Figure 27. Location of Shell Groups On A Skid

TABLE XIX. NUMBER OF DEFECTS PER POSITION BY LOCATION

Location	No. Shells Per Location	B.A.K* Studies 1	2	Total This Study
Outside Ring	28	7.5	4.0	17.32
Middle Ring	20	10.0	6.6	20.45
Inner Ring	12	14.5	6.0	20.58
Outside Corners	4	5.0	1.75	15.75
Four Center Positions	4	16.5	7.75	19.25
Front Half	30	9.4	5.0	18.23
Back Half	30	10.3	5.5	19.80
Right Half	30	9.76	5.83	18.93
Left Half	30	9.96	4.76	19.10

*B.A. Kavanaugh

The original assumption was that relative environment of a shell affected the formation of defects. Thus, shells located in the middle ring would have a different environment than shells located in the outside ring, etc. The results of Mr. B.A. Kavanaugh's first two studies indicated that this was an acceptable conclusion; but it did not hold up in later studies. A similar analysis was performed on the data obtained in this study.

Table XIX represents defect frequency by location. As can be seen the corner positions always have a low defect frequency; the center positions have a high defect frequency; and the outside ring has a lower defect frequency than the inner positions. No apparent frequency difference exists when the skid is divided into halves. This is clearly demonstrated by the B.A.K. studies which were conducted on production samples. This study is similar in trend but the significance is masked since some of the skids contained as high as 90% defects.

From Table XIX results, it appeared that shell environment may affect the formation of cavities. However, when each shell position was analyzed separately (Table XX), a different pattern was noted. It was found that certain shell positions had much higher than the average number of defects, while a few others had much lower than the average number of defects. Figure 28 shows the combined total defects from the three studies per shell position. One very interesting observation was that most of the low defect positions were at the handle end of the skid. This is the end which faces the center aisle of the cooling bay. Most of the high defect positions are located in the inside positions on the skid.

The conclusion to be made is that shell position on the skid and possibly the position of the skid in relation to other large objects may affect the cooling rate and hence the formation of defective shells.

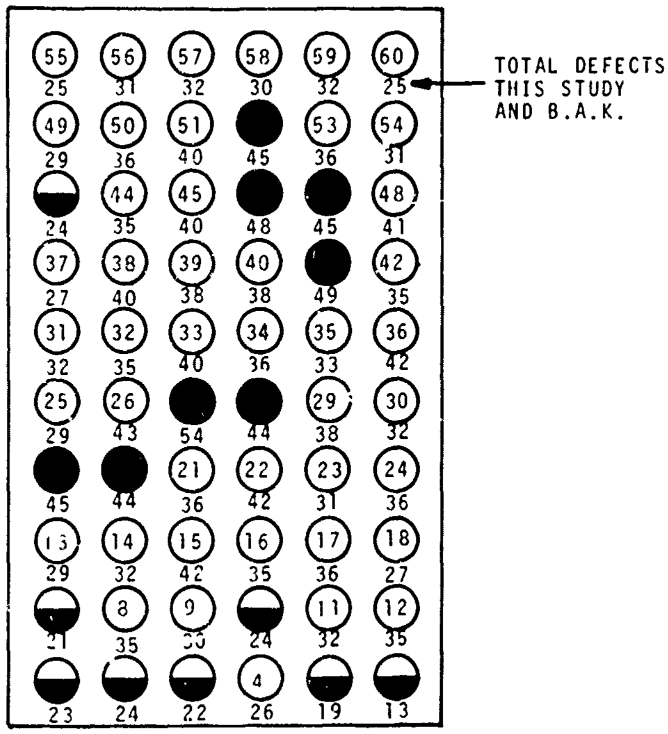
It should be noted that there are other factors which could bias the results of these studies. One of these factors is the difference in ambient cooling bay conditions in the summer and winter months. Most of these studies were conducted during the warmer weather and might be different if conducted during the cooler months. Another factor not considered is the possibility that the defect frequencies may relate to multipour position and not skid positions, since the multipours have 60 pouring stations similar in configuration to the skid positions.

TABLE XX. DEFECT SUMMARY STUDY BY POSITION

Shell Position	This Study	B.A.K* Studies 1	2	Total	Shell Position	This Study	B.A.K* Studies 1	2	Total
1	15	5	3	23	31	15	14	3	32
2	15	6	3	24	32	18	11	6	35
3	13	7	2	22	33	15	17	8	40
4	16	4	6	26	34	17	15	4	36
5	12	6	1	19	35	16	13	4	33
6	11	2	0	13	36	20	9	13	42
7	15	6	0	21	37	12	11	4	27
8	19	14	2	35	38	20	12	8	40
9	19	7	4	30	39	21	11	6	38
10	18	5	1	24	40	21	12	5	38
11	17	8	7	32	41	22	17	10	49
12	19	9	7	35	42	18	13	4	35
13	19	5	5	29	43	17	6	1	24
14	20	8	4	32	44	20	7	8	35
15	24	12	6	42	45	20	16	4	40
16	22	11	2	35	46	22	19	7	48
17	22	7	7	36	47	25	14	6	45
18	12	10	5	27	48	26	11	4	41
19	21	19	5	45	49	22	3	4	29
20	22	15	7	44	50	25	5	6	36
21	19	12	5	36	51	25	8	7	40
22	21	15	6	42	52	24	6	15	45
23	18	5	8	31	53	21	11	4	36
24	22	10	4	36	54	17	7	7	31
25	17	6	6	29	55	20	4	1	25
26	20	13	10	43	56	20	8	3	31
27	25	19	10	54	57	20	12	0	32
28	20	15	9	44	58	17	8	5	30
29	18	13	7	38	59	21	5	6	32
30	16	8	8	32	60	17	5	3	25

*B.A. Kavanaugh

A COMPLETELY SHADED CIRCLE INDICATES THAT THE POSITION WAS ONE OF THE EIGHT HIGHEST WHILE A HALF-SHADED CIRCLE INDICATES ONE OF THE EIGHT LOWEST POSITIONS.



HANDLE

Figure 28. Total Defects Per Position For the Three Studies

2.11 VISCOSITY.

The original theory proposed regarding viscosity was that a high viscosity explosive will entrap more air than a low viscosity explosive during melting, agitation, pouring and the early stages of the cooling process. Since the assumption was made that trapped air caused or helped cause cavities, the logical conclusion was to use a low viscosity explosive and thus maximize the potential for air to escape. The practice of sorting Comp B by box and using only material at 5 seconds viscosity or less had been introduced in the production process at both Joliet and Kansas AAP. For the first three weeks of the testing program, sorted low viscosity Comp B was used with a maximum viscosity of 5 seconds. Later a series of tests were performed to determine what effect viscosity had on the formation of cavities. The tests consisted of pouring 105mm shells with Comp B manufactured with Petrolite wax which had a viscosity of 5 to 7 seconds (high viscosity Petrolite). The results are shown in Table XXI. These results did not demonstrate that viscosity affected the formation of cavities. The hand sorting of Comp B was then terminated in all remaining tests.

TABLE XXI. RESULTS OF SORTED HIGH AND LOW VISCOSITY TESTS

	Viscosity				
	High		Low		
Test	G-1	G-2	E-5	E-6	E-1
Explosive Temperature	174-177	176-177	175-179	175-178	175-177
Steel Temperature	70-78	73-80	69-74	72-75	75-78
Percent Scrap	0	70	0	70	0
Number of Skids	20	10	10	12	11
Total Defects	0	0	0	0	0

Later tests did not produce any data to substantiate the claim that viscosity (up to 7 seconds) affected the formation of cavities in the explosive casts. When the Comp B with Grade B waxes were later used on a regular production basis, the Comp B was used as received without sorting.

2.12 FIBER WASHERS.

Fiber washers approximately 1/16 inch thick were inserted between the riser and the shell. This approach was intended to minimize heat transfer from the funnel to the shell body and to increase the solidification time for the explosive in the neck of the riser. With this accomplished, it would be reasonable to expect fewer cavities to occur at higher (above 79°F) initial shell temperatures. The results of the comparison tests between shells with and without fiber washers are presented in Table XXII. From these results it is obvious that fiber washers do not provide any significant improvement to the process. As a result of these tests, no additional fiber washer tests (with the exception of water cooled skids) were performed.

TABLE XXII. RESULTS OF TEST WITH AND WITHOUT FIBER WASHERS BETWEEN THE RISER AND THE SHELL

	No Fiber Washers				Fiber Washers			
Shell Temperature	83	82	83	83	82	84	84	85
Explosive Temperature	179	179	179	179	178	180	179	179
Defects	8	0	2	3	0	0	0	4
Shell Temperature	86	89			86	86		
Explosive Temperature	180	180			180	180		
Defects	3	33			3	1		
Shell Temperature	84	84			84	83		
Explosive Temperature	184	184			184	183		
Defects	4	10			7	10		

2.13 BAD LOT PETROLITE.

During the time this test program was being carried out, one of the loading plants commented that they were having difficulties producing acceptable explosive casts using certain lots of Comp B. These lots were dubbed "Bad Lot Petrolite" as Petrolite wax was used in the manufacture of the explosive. The two lots in question were HOL-053-5095 and HOL-053-5137. A series of tests were performed to determine the validity of these claims. The results of these tests are given in Table XXIII.

TABLE XXIII. RESULTS OF BAD LOT PETROLITE TESTS

LOT NO. HOL-053	5095	5095	5095	5137
Test	H-1	H-2	H-3	N-1
Explosive Temperature	173-178	175-180	175-178	175-177
Steel Temperature	75-78	73-79	72-75	74-76
Percent Scrap	0	40	0	0
Number of Skids	20	20	19	19
Total Defects	1	0	0	0

There was one critical defect produced in test, H-1. Prior to the time this skid was being poured, adverse operating conditions were being experienced due to air and power failures. Due to the nature of the operation it was not feasible to hold the explosive in the system. Since none of the subsequent tests involving "Bad Lot" Petrolite Comp B produced defects, the critical defect was attributed to the adverse operating conditions experienced at the time the skid was poured. Since these results were not any different than previous or later tests in the 72° to 79°F steel temperature, and 173° to 180°F explosive temperature region, it was concluded that the loading difficulties could not be attributed to the explosive.

SECTION III

LABORATORY TESTS

3. LABORATORY WORK.

As an adjunct to the process variable studies, sample shells were selected for sectioning to confirm the nature of voids and cavities determined by X-ray and to provide samples for laboratory analysis of the cast Comp B. Laboratory samples were taken from center sections, outside areas of the cast, at the bottom approximately 4 inches below the former intrusion, and just under the former. Samples were analyzed for wax content, RDX content and density. Data analysis is shown in Tables XXIV, XXV and XXVI. An overall summary for samples of Comp B having Petrolite or Indramic wax is shown by Figures 29, 30 and 31.

3.1 WAX CONTENT. (See Figure 29 and Table XXIV).

All samples tested satisfied the minimum wax content of .7% in Comp B. The data cover a wide range of explosive temperature, shell temperature, and varying degrees of wax segregation as visually detectable in the melt kettle, multipour reservoir or in the risers. Thus there is data to show that these factors do not significantly relate to the wax content carried into the cast. The higher wax content in the B sample, center of shell, which is the last area to solidify, is probably the result of wax tendency to segregate as freezing front progresses.

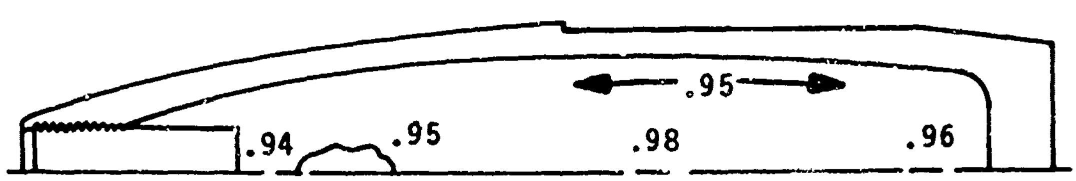


Figure 29. Wax Analysis (%)

TABLE XXIV. WAX CONTENT

Group	Test	Skid	No.	Def.	Outside of Cast A	Outside of Cast B	Outside of Cast C	Inside of Cast A	Inside of Cast B	Inside of Cast C	C Top	Riser Bot	Riser Inter-Face	Riser Top
A	1	11	32	No	.93	1.01	.95	.98	.99	.96	-	-	-	-
A	9	1	55	Yes	.97	.94	.93	1.05	1.01	.93	.93	-	-	-
D	4	7	2	Yes	.91	.92	.90	.94	.93	.88	.86	.87	.87	.85
D	5	14	49	No	.98	.96	1.00	.97	1.01	.99	-	.99	.99	.99
F	DP	17	6	No	.74	.75	.74	.71	.83	.73	-	-	-	-
F	DP	17	19	Yes	.73	.78	.78	.72	.75	.72	.75	-	-	-
H	1	18	43	Yes	1.00	1.00	1.00	1.02	1.05	1.02	.99	-	-	-
H	DP	21	59	Yes	1.04	1.00	.99	1.06	1.06	1.04	1.02	-	-	-
I	3	9	56	Yes	.74	.73	.74	.69	.77	.75	.67	-	-	-
J	1	3	1	No	.70	.73	.72	.70	.73	.73	-	.71	.78	.72
J	3	9	41	Yes	.95	.91	.97	.95	1.00	.95	.96	1.07	.93	1.00
J	5	3	47	Yes	.89	.90	.87	.91	.93	.94	.91	.85	.81	.97
J	6	10	32	Yes	.89	.91	.90	.94	.84	.90	.79	.90	.86	.73
J	12	17	58	Yes	.93	.87	.94	.92	1.01	.93	1.05	.90	.70	.60
J	14	7	60	No	-	-	-	.99	.97	1.03	-	-	-	-
J	15	17	48	No	-	-	-	1.00	.97	.93	-	-	-	-
L	1	30	18	Yes	-	-	-	.89	.89	.91	.80	.84	.84	.86
L	2	10	48	Yes	-	-	-	.81	.78	.78	.81	.73	.78	.75
L	3	14	6	Yes	-	-	-	1.04	1.04	1.06	.94	1.01	.97	1.01
W	1	7	59	Yes	-	-	-	.92	.97	.90	.88	.94	.99	.94
W	1	7	7	Yes	-	-	-	.95	.98	.89	.88	.93	.88	.83
K	22	1	20	Yes	-	-	-	.91	.91	.86	.81	.88	.86	.83

3.2 RDX CONTENT. (See Figure 30 and Table XXV).

These data show a slight tendency for RDX to settle at the center of the cast, or the last position to solidify. Figure 30 shows related samples with Indramic wax, for shell with or without a "C" segment cavity. When a cavity does occur, the material just under the former has a lower RDX content than the material around the lower portion of the cavity, and the center of shell is higher in RDX by 2%, compared to a shell without a cavity.

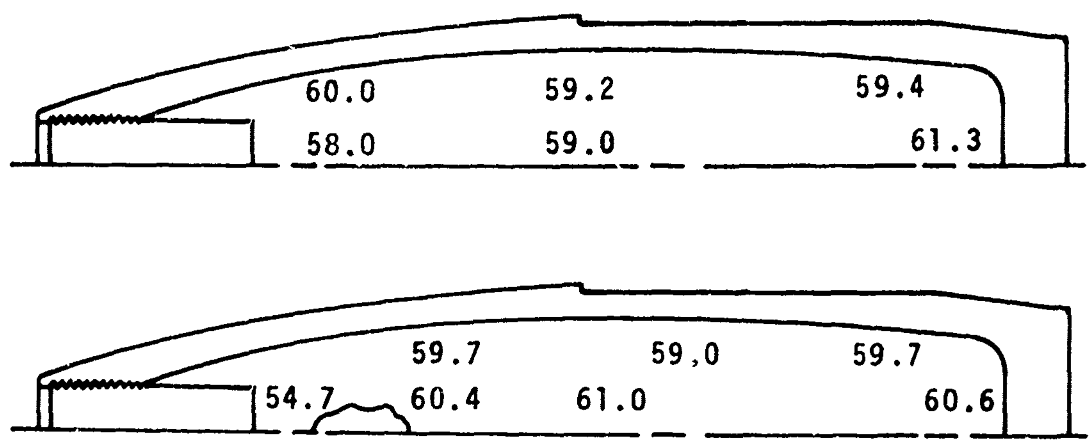


Figure 30. RDX Analysis (%)

TABLE XXV. RDX CONTENT

					Outside			Center				Riser		
GR	Test	SK	No.	Def.	A	B	C	A	B	C	C Top	Bot	Inter-Face	Top
I	3	9	56	Yes	59.4	58.7	59.0	60.0	61.8	59.9	55.2	-	-	-
J	1	3	1	No	59.4	59.2	60.0	61.3	59.0	59.0	-	59.7	62.1	60.6
J	3	9	41	Yes	59.6	59.7	59.7	60.3	61.9	61.2	55.7	57.9	60.7	62.0
J	5	3	47	Yes	60.9	59.4	59.3	61.6	61.3	61.5	54.4	58.6	60.4	62.3
J	6	10	32	Yes	59.4	58.4	60.7	60.1	60.9	59.4	55.1	58.0	58.5	60.1
J	12	17	58	Yes	58.7	58.8	59.5	60.1	60.9	60.1	53.1	57.5	60.8	62.3
J	14	7	60	No	-	-	-	61.0	61.5	57.9	-	-	-	-
J	15	17	48	No	-	-	-	61.8	60.0	57.2	-	-	-	-
L	1	30	18	Yes	-	-	-	61.1	60.7	59.9	58.0	60.0	59.7	61.8
L	2	10	48	Yes	-	-	-	60.3	58.7	61.1	55.9	58.2	59.9	60.8
L	3	14	6	Yes	-	-	-	60.8	60.1	59.3	53.2	58.0	58.8	62.8
W	1	7	59	Yes	-	-	-	60.4	60.6	59.9	57.7	56.9	60.3	61.8
W	1	7	7	Yes	-	-	-	60.2	60.5	61.6	55.7	59.2	59.1	59.9
K	22	1	20	Yes	-	-	-	61.3	59.1	58.5	56.5	60.3	56.9	58.8

3.3 DENSITY. (See Figure 31 and Table XXVI).

Density data shows a consistent pattern for any of the waxes used. Figure 31 lumps data from a straight single pour process with Indramic, Petrolite and Castor wax. The first areas to solidify, the periphery of the cast, averages 1.70 gm/cc. The center of the cast averages 1.68 gm/cc whether or not a cavity is formed. Density just under the former is 1.63 gm/cc for shell without a cavity, and 1.65 to 1.67 for material around a cavity when one does form. If the cavity is taken into account, the overall density would be less than 1.63 gm/cc. Overall, the data shows that the last portion to solidify has the lowest density, and points up the importance of maximizing capability for mass transfer of the material reservoir in the riser.

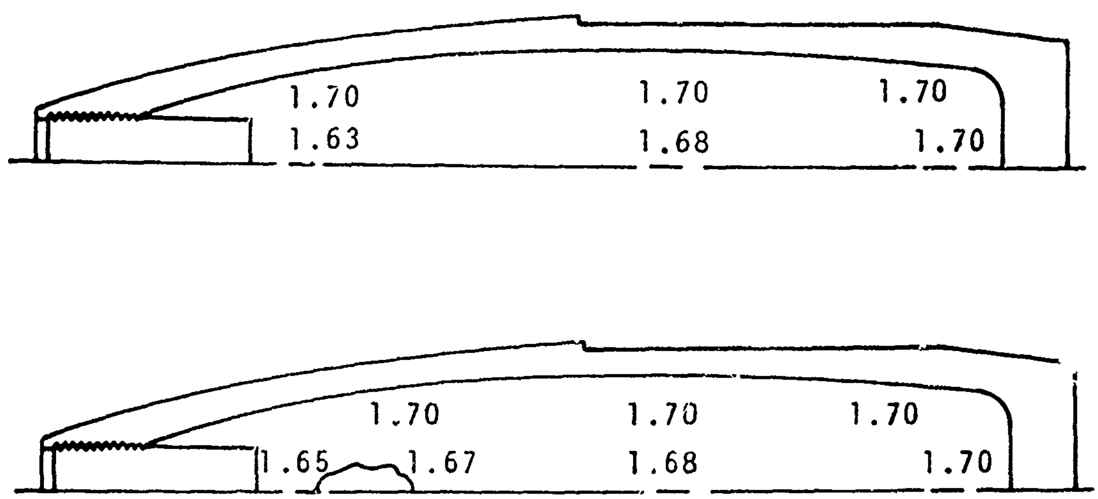


Figure 31. Density Analysis gm/cc

TABLE XXVI. DENSITY

Shell Group	Test	Skid	No.	Def.	Outside of Cast A	Outside of Cast B	Outside of Cast C	Center of Cast A	Center of Cast B	Center of Cast C	C Top	Bot	Riser Inter-Face	Top Riser
A	1	11	32	No	1.69	1.69	1.73	1.70	1.67	1.61	-	-	-	-
A	9	1	55	Yes	1.70	1.70	1.68	1.71	1.68	1.66	1.62	-	-	-
D	4	7	2	Yes	1.70	1.69	1.70	1.70	1.68	1.66	1.63	1.68	1.69	1.68
D	5	14	49	No	-	-	-	-	-	-	-	-	-	-
F	DP	17	6	No	1.71	1.69	1.69	1.70	1.66	1.64	-	-	-	-
F	DP	17	19	Yes	1.70	1.69	1.68	1.70	1.66	1.66	1.65	-	-	-
H	1	18	43	Yes	1.72	1.72	1.70	1.71	1.70	1.69	1.67	-	-	-
H	DP	21	59	Yes	1.71	1.70	1.70	1.70	1.69	1.69	1.66	-	-	-
I	3	9	56	Yes	1.72	1.71	1.70	1.70	1.68	1.67	1.64	-	-	-
J	1	3	1	No	1.70	1.70	1.70	1.70	1.68	1.64	-	1.70	1.70	1.69
J	3	9	41	Yes	1.71	1.70	1.68	1.71	1.68	1.67	1.66	1.69	1.69	1.70
J	5	3	47	Yes	1.70	1.70	1.70	1.70	1.70	1.66	1.66	1.69	1.70	1.69
J	6	10	32	Yes	1.71	1.70	1.71	1.70	1.68	1.66	1.65	1.67	1.69	1.70
J	12	17	58	Yes	1.71	1.70	1.69	1.70	1.68	1.67	1.67	1.68	1.70	1.70
J	14	7	60	No	-	-	-	1.71	1.68	1.67	-	-	-	-
J	15	17	48	No	-	-	-	1.70	1.68	1.68	-	-	-	-
L	1	30	18	Yes	-	-	-	1.70	1.69	1.68	1.61	1.71	1.69	1.69
L	2	10	48	Yes	-	-	-	1.71	1.68	1.66	1.66	1.65	1.69	1.69
L	3	14	6	Yes	-	-	-	1.71	1.69	1.68	1.64	1.68	1.68	1.65
W	1	7	59	Yes	-	-	-	1.71	1.67	1.67	1.67	1.68	1.68	1.70
W	1	7	7	Yes	-	-	-	1.70	1.67	1.66	1.66	1.67	1.69	1.68
K	22	1	20	Yes	-	-	-	1.70	1.67	1.68	1.67	1.68	1.69	1.69

3.4 SPLIT PHOTOGRAPHY.

The splits confirm the X-ray films for defects. For shells which do not have a void, an area showing porosity is apparent under the former and is usually detectable in X-ray. There were no instances of base separation noted, and the half-cast cannot be easily removed from the metal part. The splits frequently show "pock marking" around the lower peripheral portion of the cast. These were noted to occur in both cool shell (70-75°F) and hot shell (90°F) and at any explosive pour temperature. The splits from double pour experiments show an interface only at the outer areas where the freezing first occurs. Aside from the pock marks, the only observations of any concern, revealed in a split and not apparent by X-ray, are the cracks and cracking patterns which developed when a water cooling system was used.

SECTION IV

PRODUCTION PROCESS COMMENTS

4. GENERAL.

It is thought desirable at this point to discuss generally the effect of process variables in cast loading of the 105mm M1 shell. As previously demonstrated, the primary variables which must be controlled are shell steel and explosive temperature. The whole cast loading process involves an intricate balance of heat flow and solidification (crystallization) characteristics of explosive. Any action or variable which effects this in any way inevitably has some effect on the process. Since the mass of the projectiles, and the mass of explosives are the largest mass factors in the system, it is easy to see why they are the prime temperature variable factors which must be controlled. If the remaining variable factors are controlled, it becomes easier to establish the particular range of steel and explosive temperatures required to obtain an optimum cast. Factors, believed to fall in the above category, are delineated below.

4.1 VIRGIN VS SCRAP.

Throughout the entire test program the scrap versus explosive ratio was monitored. Review of the data indicated that casts with scrap (reworked) explosive generally yielded less defects than casts with virgin material. No conclusive evidence for the cause of this was found; however, it is thought that material which has been remelted may contain less trapped air. It would seem prudent to provide for uniform scrap usage in the cast loading process and eliminate this as a process variable in production.

4.2 RISER HEIGHT.

During tests it was noted that defective shells sometimes coincided with "low" riser heights. Several explanations for this have been proposed, none of which is conclusive in itself. The first being that a low riser does not contain a sufficient reservoir of hot material to properly retard cooling in the nose and riser section of the shell. Another reason being a lower riser does not exert sufficient pressure to provide for mass flow into the cooling shell. Again it seems more prudent to assure a full and uniform riser height and eliminate this as a production variable.

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4.3 MULTIPOUR EQUIPMENT FACTORS.

Variable factors peculiar to the individual multipour arrangement include degree of agitation, reservoir level, and the possibility that air is injected into the explosive during cupcharging. Again no conclusive evidence was found linking these variables to defective casts; however, sufficient agitation to assure uniform explosive temperature and to prevent RDX settling in the multipour reservoir should be provided. A constant reservoir level sensing device with automatic feed is desirable. To prevent the agitators from injecting air into explosive during cupcharging, an interlock was installed with the vacuum draw during these loading trials.

4.4 FOREIGN MATERIAL.

Accumulations of wax, lubricant, solidified explosive and other items can build up on various parts of the system and can inadvertently be cast in the shell. If accumulations are sufficient, defective casts can be caused as indicated in Figure 32, which was caused by a glob of wax purposely placed in the cast. Good housekeeping is obviously important.

Figure 32. Defect Caused by Glob of Wax

4.5 SHROUD.

The wood shroud with baffle was shown to be slightly more effective than the canvas shroud in the test results. The degree of improvement was not as significant as originally anticipated, and under ideal production conditions may not be necessary. However, the wood shroud with baffle does tend to give uniform conditions less subject to extraneous variables such as cooling bay temperature, air movement, or proper placement on the skid. The canvas shroud is subject to variations from each of these conditions. It is therefore concluded that the use of the more efficient shroud is warranted even though the defect rate between the two shrouds is not statistically significant.

4.6 SKID TEMPERATURE.

The skid used in loading process contains a relatively large mass of steel. In the first stages of test during hotter weather, defects were noted when shell steel temperature exceeded 80°F. During later stages of tests, in cooler weather, a similar level of defects were not noted until shell steel temperature exceeded 83 to 84°F. One possible explanation for this was that the skid was significantly cooler during the later stages of test. From this it is concluded that some control of skid temperature could aid materially in eliminating a process variable.

4.7 PROJECTILE WEIGHT STUDY.

Prior to initiation of this program it was hypothesized that variation in projectile MPTS weight might adversely effect the cast quality of the shell. At the start of this program 500 projectiles were selected from a metal parts lot and the weights were recorded. The projectile weights proved to be fairly uniform and are not considered to be a factor effecting cast quality. Details of the Projectile Weight Study are contailed in Appendix B.

4.8 PRODUCTION SUMMARY.

The first attempts to load Comp B with Grade B wax (Petrolite) in the 105mm M1 projectile at JAAP occurred 4-29 May 1973. During this period 241,847 projectiles were loaded. Frequent and extensive 100% X-ray inspection was required, due to the occurence of "C" segment cavitation defects. A total of 71,587 projectiles required X-ray inspection during this period yielding an apparent production defect rate up to 3%. Loading with Comp B with Grade B wax was discontinued at this point. One additional attempt to load Comp B with Grade B wax was made 6-12 July 1973 with similar unsatisfactory results.

After several weeks of trial loading in early September, it became apparent that projectile MPTS temperature prior to pour and explosive material temperature were the key variables. It was felt that production loading Comp B with Grade B wax could be accomplished by controlling these variables. Accordingly a projectile MPTS temperature of 79°F maximum and an explosive temperature of 176 $\pm$ 3°F was established as a process control criteria. Additionally, the insulated wooden box shroud was simultaneously implemented into production. Using this production criteria, JAAP has successfully loaded Comp B with Grade B wax (Petrolite, ES 670 and Indramic 170C) since September 1973. Approximately 2 million shells have been loaded through July 74, with 100% X-ray inspections required on only 3 occasions. On two occasions the use of cold shells (a previously known cause for defects during cold months) and on one occasion foreign material were identified as the cause of their defects.

SECTION V

CONCLUSIONS

5. CONCLUSIONS.

The following conclusions are made as a result of this program.

5.1 EXPLOSIVE.

1. Comp B using Indramic 170C or Petrolite ES670 Grade B waxes can be used in the 105mm projectile within the limits of projectile (65° to 79°F) and explosive (176° ± 3°F) temperatures established by this program. Projectile temperature is the prime consideration.

2. Comp B using Sunoco 8810 Grade A wax gives good quality casts over a broader range of process temperatures.

3. The addition of SPAN 85 does not improve the casting properties of Comp B using Indramic or Petrolite wax.

4. Comp B using Castor wax (Grade B wax) cannot be used with the same process limits defined for Indramic or Petrolite wax.

5. Segregation of Comp B by viscosity (less than 5 seconds and 5 to 7 seconds) was not meaningful. There is no significant effect on cast quality.

6. There were no differences noted in the behavior or effect on cast quality of different lots of Comp B using different lots of Petrolite wax.

7. The reuse of process scrap can improve cast quality.

5.2 PROCESS.

1. Shell temperature is the most significant factor in the use of Comp B with Grade B wax. An upper limit of 79°F is required to avoid "C" segment defects.

2. Explosive pour temperature is a significant factor in the production of good explosive casts.

3. Shroud type and shroud efficiency are not overriding factors affecting cast quality, but efficient shrouding is considered to be helpful.

4. The use of probing, double pouring, or hot topping techniques were not effective process techniques and did not provide a means for reducing "C" segment cavities.

5. Forced cooling (water cooling) may be a method of minimizing "C" segment defects, but can cause cracking of the entire cast which is potentially more hazardous and in some cases may not be detectable by X-ray.

5.3 OTHER.

1. Projectile weight variations are not an area of concern regarding cast quality.

2. Gridding techniques for measuring the projected area of a void of an X-ray were not helpful in interpreting X-rays and defining cavitation criteria.

3. Laboratory analyses of cast Comp B from the 105mm M1 shell show data consistent with theoretical analyses of the loading operation.

4. Different projectile locations on the skid may give different defect frequencies.

SECTION VI

RECOMMENDATIONS

6. RECOMMENDATIONS.

1. It is recommended that provisions be made to cool the projectile metal parts prior to pouring, within the process limits of 65°F to 75°F, for loading operations during the hotter months.

2. The use of some form of efficient shroud is recommended in order to minimize variations encountered in the cooling process.

3. It is recommended that the processes and materials used in the loading operation be controlled so as to maintain a maximum degree of consistency. It is the opinion of the authors that this is the key which enables successful production operations.

4. It is believed that tests on a large scale basis (such as encompassed by this report) are necessary for proving producability of items loaded with Comp B with a newly qualified wax or additive. It is recommended that testing on a similar scale be accomplished when new Comp B waxes or additives are considered for phase-in to production operations.

APPENDIX A

CAVITATION REQUIREMENTS (MIL-C-45195)

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4. <u>Cavitation Requirements</u> (MIL-C-45195)

<u>Projected Cavities</u>

Cavities with a projected length of 1/32 inch or less will be disregarded. Cavities within the explosive charge will not exceed the requirements specified in Table I.

TABLE I	SEGMENT A	B	C	D
Sum of projected areas of the cavities, excluding pipes, cracks and annular rings, square inch	1/64*	1/4	1/2	1/2
Projected length of any cavity, excluding pipes, cracks and annular rings (in.)	1/8	1/2	1/2	3/4
Piping cavities, maximum projected area (sq. in.)	0	1/4	1/2	0
Piping cavities, maximum projected width (in.)	0	1/4	1/4	0
Cracks, maximum projected width (in.)	1/32	1/32	1/32	—
Annular rings, max. projected width (in.)	0	0	1/4	0

*If the length of the largest cavity is 1/16 inch or less, the maximum total projected area may be 1/20 square inch.

<u>Porous Areas</u>

Porous areas will be treated as cavities and be subject to the same restrictions except that 80% of the projected length and 80% of the projected area will be considered for acceptance purposes.

<u>Cracked Charges</u>

Not more than two transverse cracks will be permitted on any charge, and not more than one transverse crack will be permitted in Segment A. Cracks in Segment D will be disregarded.

<u>Surface Cavitation</u>

Surface cavitation is determined by visual inspection after cavity drilling and cleaning. If a defect is detected by X-Ray in Segment C and is visually detectable as excessive cavitation, it will be marked as such, but not reported as an X-Ray defect.

Cavities formed due to chipped or broken explosive from the sidewalls of the fuze well will not extend in aggregate around more than 1/4 of the circumference. Cavities in the base of the fuze well cavity will not be cause for rejection provided the sum of the areas of the cavities is not greater than 80% of the area of the base and no individual point extends more than 1/4 inch below the maximum depth of the fuze well permitted by the drawing, and provided no point extends above the flat surface on which the liner would rest. Cavities with a maximum dimension of 1/32 inch or less as well as <u>all</u> voids in the area from the top of the shell down three inches into the fuze well will be disregarded.

5. <u>Cavitation Defects</u>

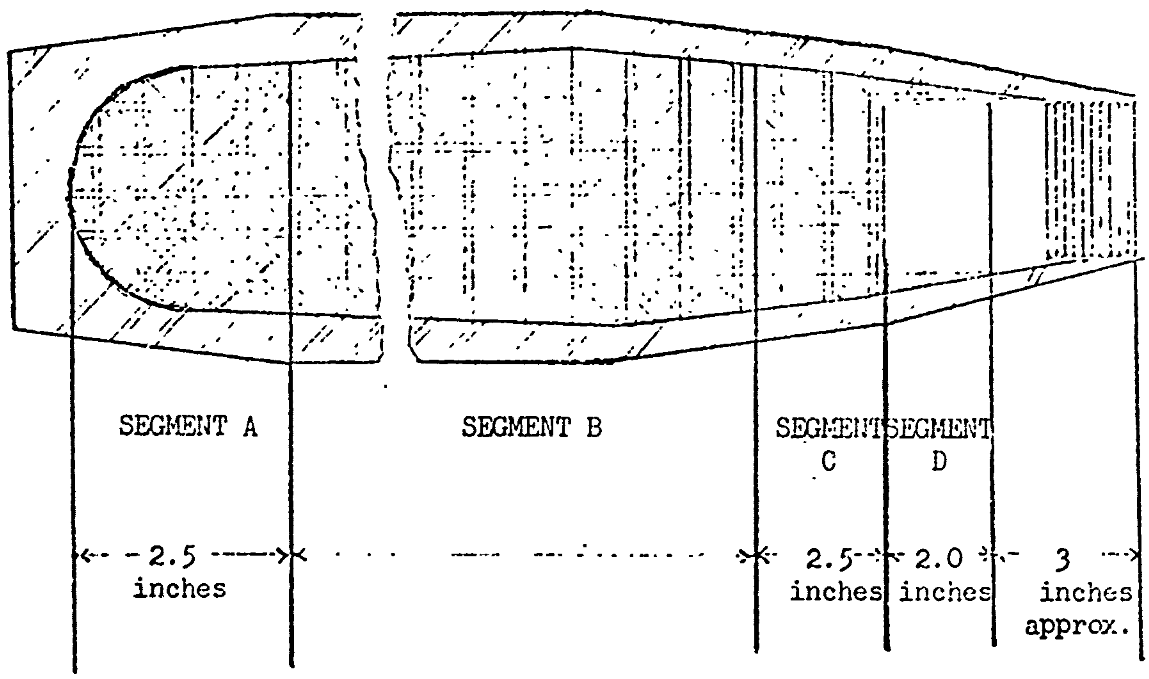
<u>Critical Defects</u>:

<u>Code No.</u>	<u>Defect</u>
14001	Cavitation, cracks or annular rings in Segment A in excess of that permitted in Table I.
14002	Cavitation, cracks or annular rings in Segment B, C, or D in excess of twice that permitted in Table I.
14003	Cracks in excess of that permitted under <u>cracked charges</u> above.
14004	Base separation. There shall be no separation between the shell base and the charge. In the event an original x-ray picture leaves doubt as to acceptability, the cartridge shall be re-x-rayed at an angle 90° from that of the original exposure and in the same plane.

<u>Minor Defect</u>:

14005	Cavitation, cracks or annular rings in Segment B, C, or D in excess of that permitted by Table I, but not more than twice that permitted by Table I.

105MM PROJECTILE



APPENDIX B

PROJECTILE WEIGHT STUDY

PALLET #1 PROJECTILE LOT NO. NPK 1-765

1.	25.83	21.	25.89	41.	25.86	61.	25.84
2.	25.92	22.	25.90	42.	25.95	62.	25.86
3.	25.94	23.	25.82	43.	25.87	63.	25.85
4.	25.87	24.	25.85	44.	25.95	64.	25.89
5.	25.90	25.	25.88	45.	25.84	65.	25.87
6.	25.93	26.	25.93	46.	25.87	66.	25.86
7.	25.88	27.	25.89	47.	25.85	67.	25.91
8.	25.81	28.	25.86	48.	25.93	68.	25.82
9.	25.93	29.	25.91	49.	25.89	69.	25.94
10.	25.93	30.	25.87	50.	25.89	70.	25.92
11.	25.93	31.	25.93	51.	25.94	71.	25.85
12.	25.87	32.	25.89	52.	25.89	72.	25.94
13.	25.88	33.	25.85	53.	25.95	73.	25.92
14.	25.90	34.	25.86	54.	25.93	74.	25.90
15.	25.85	35.	25.96	55.	25.87	75.	25.84
16.	25.86	36.	25.86	56.	25.89	76.	25.87
17.	25.94	37.	25.87	57.	25.96	77.	25.87
18.	25.82	38.	25.88	58.	25.95	78.	25.88
19.	25.87	39.	25.82	59.	25.93	79.	25.99
20.	25.88	40.	25.89	60.	25.92	80.	25.85

PALLET #2 PROJECTILE LOT NO. NPK 1-765

1.	25.93	21.	25.90	41.	25.89	61.	25.84
2.	25.91	22.	25.82	42.	25.82	62.	25.92
3.	25.89	23.	25.80	43.	25.87	63.	25.87
4.	25.87	24.	25.87	44.	25.84	64.	25.90
5.	25.89	25.	25.83	45.	25.92	65.	25.88
6.	25.91	26.	25.88	46.	25.89	66.	25.89
7.	25.89	27.	25.96	47.	25.87	67.	25.94
8.	25.83	28.	25.87	48.	25.90	68.	25.89
9.	25.86	29.	25.88	49.	25.89	69.	25.82
10.	25.90	30.	25.93	50.	25.83	70.	25.86
11.	25.79	31.	25.91	51.	25.85	71.	25.92
12.	25.88	32.	25.81	52.	25.91	72.	25.87
13.	25.77	33.	25.82	53.	25.86	73.	25.87
14.	25.84	34.	25.84	54.	25.89	74.	25.84
15.	25.90	35.	25.90	55.	25.89	75.	25.86
16.	25.88	36.	25.88	56.	25.86	76.	25.79
17.	25.90	37.	25.88	57.	25.91	77.	25.95
18.	25.86	38.	25.89	58.	25.94	78.	25.84
19.	25.88	39.	25.85	59.	25.83	79.	25.87
20.	25.90	40.	25.87	60.	25.84	80.	25.93

PALLET # 3 PROJECTILE LOT NO. NPK 1-765

1.	25.76	21.	25.89	41.	25.83	61.	25.89
2.	25.87	22.	25.89	42.	25.85	62.	25.92
3.	25.87	23.	25.82	43.	25.83	63.	25.93
4.	25.85	24.	25.83	44.	25.89	64.	25.81
5.	25.88	25.	25.88	45.	25.84	65.	25.84
6.	25.91	26.	25.85	46.	25.89	66.	25.86
7.	25.87	27.	25.92	47.	25.82	67.	25.93
8.	25.79	28.	25.86	48.	25.94	68.	25.81
9.	25.89	29.	25.84	49.	25.85	69.	25.84
10.	25.95	30.	25.86	50.	25.89	70.	25.83
11.	25.91	31.	25.90	51.	25.84	71.	25.87
12.	25.89	32.	25.86	52.	25.92	72.	25.86
13.	25.90	33.	25.83	53.	25.91	73.	25.87
14.	25.83	34.	25.90	54.	25.89	74.	25.83
15.	25.77	35.	25.84	55.	25.83	75.	25.85
16.	25.82	36.	25.90	56.	25.83	76.	25.93
17.	25.93	37.	25.86	57.	25.90	77.	25.84
18.	25.81	38.	25.90	58.	25.86	78.	25.88
19.	25.97	39.	25.89	59.	25.80	79.	25.82
20.	25.85	40.	25.80	60.	25.89	80.	25.82

PALLET # 4 PROJECTILE LOT NO. NPK 1-765

1.	25.83	21.	25.89	41.	25.93	61.	25.82
2.	25.87	22.	25.83	42.	25.85	62.	25.87
3.	25.85	23.	25.82	43.	25.92	63.	25.95
4.	25.92	24.	25.85	44.	25.89	64.	25.90
5.	25.87	25.	25.87	45.	25.83	65.	25.96
6.	25.83	26.	25.86	46.	25.87	66.	25.79
7.	25.89	27.	25.77	47.	25.85	67.	25.87
8.	25.82	28.	25.84	48.	25.90	68.	25.85
9.	25.89	29.	25.88	49.	25.90	69.	25.93
10.	25.90	30.	25.84	50.	25.86	70.	25.82
11.	25.85	31.	25.90	51.	25.91	71.	25.86
12.	25.89	32.	25.91	52.	25.89	72.	25.81
13.	25.89	33.	25.84	53.	25.84	73.	25.91
14.	25.94	34.	25.88	54.	25.92	74.	25.92
15.	25.94	35.	25.82	55.	25.90	75.	25.79
16.	25.89	36.	25.89	56.	25.79	76.	25.88
17.	25.91	37.	25.86	57.	25.74	77.	25.87
18.	25.74	38.	25.88	58.	25.85	78.	25.89
19.	25.89	39.	25.96	59.	25.74	79.	25.89
20.	25.84	40.	25.81	60.	25.93	80.	25.87

PALLET # 5 PROJECTILE LOT NO. NPK 1-765

1.	25.85	21.	25.94	41.	25.85	61.	25.80
2.	25.92	22.	25.91	42.	25.87	62.	25.90
3.	25.88	23.	25.89	43.	25.79	63.	25.87
4.	25.91	24.	25.83	44.	25.96	64.	25.81
5.	25.88	25.	25.98	45.	25.93	65.	25.84
6.	25.89	26.	25.90	46.	25.92	66.	25.86
7.	25.78	27.	25.96	47.	25.85	67.	25.83
8.	25.85	28.	25.91	48.	25.81	68.	25.87
9.	25.89	29.	25.80	49.	25.89	69.	25.90
10.	25.89	30.	25.86	50.	25.92	70.	25.89
11.	25.91	31.	25.93	51.	25.93	71.	25.90
12.	25.92	32.	25.81	52.	25.83	72.	25.82
13.	25.86	33.	25.94	53.	25.91	73.	25.81
14.	25.99	34.	25.91	54.	25.83	74.	25.82
15.	25.92	35.	25.86	55.	25.95	75.	25.90
16.	25.89	36.	25.81	56.	25.88	76.	25.95
17.	25.86	37.	25.93	57.	25.90	77.	25.87
18.	25.87	38.	25.92	58.	25.89	78.	25.86
19.	25.85	39.	25.95	59.	25.93	79.	25.90
20.	25.90	40.	25.87	60.	25.85	80.	25.89

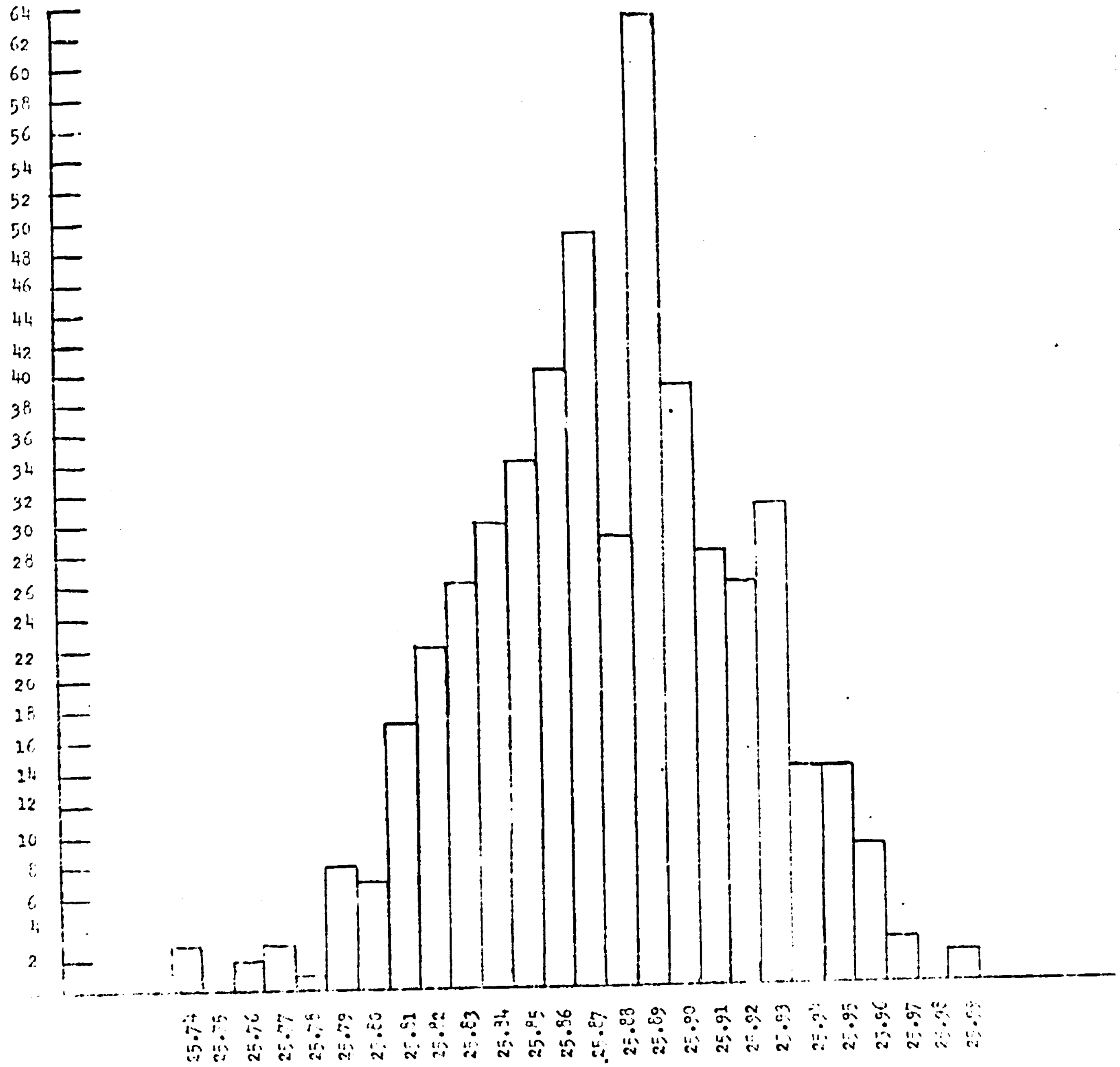
PALLET # 6 PROJECTILE LOT NO. NPK 1-765

1.	25.90	21.	25.81	41.	25.89	61.	25.91
2.	25.85	22.	25.81	42.	25.85	62.	25.87
3.	25.91	23.	25.88	43.	25.87	63.	25.83
4.	25.82	24.	25.92	44.	25.90	64.	25.84
5.	25.89	25.	25.90	45.	25.89	65.	25.90
6.	25.79	26.	25.89	46.	25.90	66.	25.91
7.	25.86	27.	25.96	47.	25.86	67.	25.95
8.	25.92	28.	25.88	48.	25.95	68.	25.96
9.	25.81	29.	25.93	49.	25.91	69.	25.89
10.	25.89	30.	25.94	50.	25.84	70.	25.95
11.	25.82	31.	25.87	51.	25.86	71.	25.87
12.	25.91	32.	25.87	52.	25.87	72.	25.93
13.	25.91	33.	25.90	53.	25.86	73.	25.92
14.	25.89	34.	25.91	54.	25.88	74.	25.80
15.	25.85	35.	25.93	55.	25.86	75.	25.80
16.	25.86	36.	25.83	56.	25.86	76.	25.90
17.	25.85	37.	25.89	57.	25.93	77.	25.84
18.	25.93	38.	25.81	58.	25.86	78.	25.97
19.	25.89	39.	25.86	59.	25.87	79.	25.94
20.	25.87	40.	25.86	60.	25.91	80.	25.95

PALLET # 7 PROJECTILE LOT NO. NPK 1-765

1.	25.84	11.	25.97
2.	25.81	12.	25.88
3.	25.93	13.	25.87
4.	25.89	14.	25.88
5.	25.82	15.	25.83
6.	25.76	16.	25.85
7.	25.84	17.	25.84
8.	25.85	18.	25.93
9.	25.92	19.	25.92
10.	25.83	20.	25.84

High	25.99
Low	25.74
Average	25.87634
Standard Deviation	0.04393



APPENDIX C

PHYSICAL PROPERTY DATA

COMPOSITION B --- PHYSICAL PROPERTY DATA

HEAT OF FUSION: 8.0 cal/gm

THERMAL CONDUCTIVITY: 6.2×10^{-4} cal/sec-cm 0°C.

COEFFICIENT OF EXPANSION:

Linear	0°C.	Length/unit length - 0°C.
	-60° to 0°	5.31×10^{-5}
	0° to 70°	6.26×10^{-5}

Volume: 4% shrinkage upon solidification

SPECIF. HEAT:	0°C.	Cal/gm/°C.
	50	0.365
	75	0.376
	85	0.354
	90	0.341
	100	0.312

DENSITY: 1.65

MELTING POINT: 78-80°C.

APPROXIMATE WEIGHT OF THE EXPLOSIVE CAST:

REFERENCES:

a) Engineering Design Handbook AMCP 706-177

b) JANAF Fuze Committee, Journal Article, Volume 1, August 1970. Published by Picatinny Arsenal

PHYSICAL DATA ON 105MM HE SHELL

WEIGHT EMPTY"	25.9 lbs.
SPECIFIC HEAT @20°C	0.1075 Cal/gm/°C
THERMAL CONDUCTIVITY:	0.17 Cal/sec/sq.cm./°C/cm
MATERIAL OF CONSTRUCTION:	Nonresulphurized carbon steel

APPENDIX D

TEST DATA

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DEFINITION OF SAMPLE POINTS AND RESULTS

A. Multipour Data

1. Reservoir Temperature -- is the temperature blend of the water as it leaves the multipour reservoir jacket sections. The temperature is obtained from a 24 hour recorder-controller and is noted at the time the skid is poured. (Marked in 2°F increments.)

2. Cup Temperature -- is the temperature blend of the water as it leaves the multipour cup jacket sections. The temperature is obtained from a 24 hour recorder-controller and is noted at the time the skid is poured. (Marked in 2°F increments.)

3. Material Temperature -- in a single pour skid this is the material temperature on the top of the riser after the skid is poured. On skids which receive two distinct pours the material temperature for the first pour is the material temperature in the reservoir just prior to filling the cups. The second pour material temperature is the material temperature in the top of the riser immediately after pouring. In all cases the temperature is obtained by using a dial thermometer marked in 2°F increments.

4. Shell Temperature -- is the temperature of the shell measured in the upper bourrelet using a pyrometer. (Marked in 5°F increments.)

5. Time Poured -- is the time of day at which the skid was poured.

6. Duration of Pour -- is the time required to pour the shells. The time interval starts when the valves at the bottom of the cups are opened and ends when the valves are closed.

7. Multipour Number -- is the pouring bay number in which the skid was poured.

B. Core Melting Data

1. Time Start -- is the time the probe started down.

2. Time Probe Down -- is the time the probe reached its prescribed depth.

3. Time Finish -- is the time the probe starts to leave the shell.

4. Probe Temperature -- is the average temperature of the probe as determined in the field.

5. Probe Steam Pressure -- is the pressure of the steam supply to the probes.

6. Core Melt Number -- is the unit number of the core melt used.

C. Cooling Bay Data

1. Cooling Bay - Position -- is the cooling bay in which the skid was placed to cool, followed by the location in the bay in which the skid was placed. Each cooling bay holds 14 skids.

2. Length of Shroud Time -- is the length of time after the skid is poured when the shroud is to be removed. The time is given in minutes.

3. Cooling Bay Temperature Averages -- this is the average of three temperatures taken at the stated locations. The temperatures are recorded at the following times:

   a. When the skid reaches its destination in the cooling bay.

   b. When the shroud is removed.

   c. At the end of the cooling period which is 3.75 hours after the skid is poured.

   The temperatures are recorded at the following locations within the bay:

A	Between	Skid	Locations	8	and	9
B	"	"	"	12	"	13
C	"	"	"	1	"	2
D	"	"	"	6	"	7
Bay	"	"	"	4	"	5

   A, B, C, and D are located 2.5 feet from the floor and 2 to 2.5 feet from the wall. The bay temperature is measured at a point 5.5 feet from the floor and 1 foot from the wall.

D. X-Ray Results

1. Number of Shells Poured -- is the actual number of acceptable shells poured. Any shell in which the Composition B level is not within 1.5 inch of the top of the riser will be deleted from the test. Any shell which received abnormal treatment which can cause a cavity will also be deleted from the test, such as probing with a cold probe before the Composition B is solidified.

2. Number of Criticals -- is the number of critical shells on the skid as defined in Item 11.

3. Number of minors -- is the number of minor shells on the skid as defined in Item 11.

4. Number of Cavities -- the number of shells with cavities.

5. Number of Good Shells -- the number of shells poured minus the number of criticals and minors.

D. X-ray Results contd.

6. Maximum Area of Cavity -- the maximum cavity area of any shell on the skid.

7. Average Area of Cavity -- total cavity area for the skid divided by the number of shells with cavities.

8. Median Area of Cavity -- is the middle observation of area in the list of areas when ordered from largest to smallest.

9. Total Area of Cavity -- is the sum of the area of all cavities on the skid.

10. Area -- is the number of full blocks plus the one half of the number of partial blocks covered by the cavity. Each block is 0.1 inch by 0.1 inch.

11. Critical Defects:

Defect

A Cavitation, cracks or annular rings in Segment A in excess of that permitted in Table I.

B Cavitation, cracks or annular rings in Segment B, C, or D in excess of twice that permitted in Table I.

C Cracks in excess of that permitted under cracked charges above.

D Base separation. There shall be no separation between the shell base and the charge. In the event an original X-ray picture leaves doubt as to acceptability, the cartridge shall be re-X-rayed at an angle 90° from that of the original exposure and in the same plane.

Minor Defect: Cavitation, cracks or annular rings in Segment B, C, or D in excess of that permitted by Table I, but not more than twice that permitted by Table I.

D. <u>X-Ray Results</u> contd.

TABLE I

	Segment			
	A	B	C	D
Sum of projected areas of the cavities excluding pipes, cracks and annular rings, square inch	1/64*	1/4	1/2	1/2
Projected length of any cavity, excluding pipes, cracks and annular rings (in.).	1/8	1/2	1/2	3/4
Piping cavities, maximum projected area (sq. in.)	0	1/4	1/2	0
Piping cavities, maximum projected width (in.)	0	1/4	1/4	0
Cracks, maximum projected width (in.)	1/32	1/32	1/32	-
Annular rings, max. projected width (in.)	0	0	1/4	0

*If the length of the largest cavity is 1/16 inch or less, the maximum total projected area may be 1/20 square inch.

NOTE:

All cavities in this report are C segment cavities appearing just under the former. No other defects were found except that a "stringer" from C segment will sometimes extend into B segment.

Test Group	Test Number	Number of Skids	Material Temperature	Steel Temperature	Percent Scrap	Probe Depth	Probe Time	Two Increment Pouring	Notes	Wax Used in Comp B
A	1	4	172-174	70-78	0				1	Low viscosity Petrolite
A	2	4	179-180	69-75	0				1	Low viscosity Petrolite
A	3	4	182-185	70-77	0				1	Low viscosity Petrolite
A	4	5	175-176	80-87	0				1	Low viscosity Petrolite
A	5	4	177-179	80-82	0				1	Low viscosity Petrolite
A	6	4	181-185	80	0				1	Low viscosity Petrolite
A	7	4	176	90-93	0				1	Low viscosity Petrolite
A	8	4	180-182	90-92	0				1	Low viscosity Petrolite
A	9	4	183-184	92-93	0				1	Low viscosity Petrolite
A	10	8	173-176	77-85	40				1	Low viscosity Petrolite
A	11	8	180-182	82-85	40				1	Low viscosity Petrolite
B	1	4	176-178	80-84	40				1,2	Low viscosity Petrolite
B	2	4	178-184	80	40				1,3	Low viscosity Petrolite
B	3	4	183-185	80	40				1,2	Low viscosity Petrolite
B	4	4	184	80-82	40				1,3	Low viscosity Petrolite
C	1	4	176-178	79-82	40	1-2	5		1	Low viscosity Petrolite
C	2	4	180-186	79-80	40	1-2	5		1	Low viscosity Petrolite
C	3	4	176-177	80-82	40	1-2	2.5		1	Low viscosity Petrolite
C	4	4	178-180	77-80	40	1-2	2.5		1	Low viscosity Petrolite
C	5	4	176-177	81	40	1-2	5	yes	1,4	Low viscosity Petrolite
C	6	4	177-178	80-81	40	1-2	2.5	yes	1,4	Low viscosity Petrolite
C	7	4	176-178	80	40	1-2	In-Out	yes	1,4,5	Low viscosity Petrolite
D	1	20	174-178	74-78	0					Petrolite with Span HOL-057-1
D	2	10	176-178	75-79	40					Petrolite with Span HOL-057-1
D	3	10	176-177	75-78	40	1-2	2.5			Petrolite with Span HOL-057-1
D	4	10	176-178	77-7[illegible]	0	1-2	2.5			Petrolite with Span HOL-057-1
D	5	11	176-178	74-79	70	1-2	2.5			Petrolite with Span HOL-057-1
E	1	11	175-177	75-78	0				1	Low viscosity Petrolite
E	2	10	175-178	75-78	0	1-2	2.5		1	Low viscosity Petrolite
E	3	10	175-176	70-71	40				1	Low viscosity Petrolite
E	4	11	175-177	68-74	40	1-2	2.5		1	Low viscosity Petrolite
E	5	10	175-179	69-74	0				1	Low viscosity Petrolite
E	6	12	175-178	72-75	70				1	Low viscosity Petrolite
F	1	4	176-179	69-74	0					Castor Wax HOL-057-3
F	2	4	174-176	92-95	0					Castor Wax HOL-057-3
F	3	4	182-184	90-93	0					Castor Wax HOL-057-3
F	4	4	185-187	70	0					Castor Wax HOL-057-3
F	5	5	177-180	70	40					Castor Wax HOL-057-3
F	8	5	175-176	70	40					Castor Wax HOL-057-3
G	1	20	174-177	70-78	0				6	High viscosity Petrolite
G	2	10	176-177	73-80	70				6	High viscosity Petrolite

Test Group	Test Number	Number of Skids	Material Temperature	Steel Temperature	Percent Scrap	Probe Depth	Probe Time	Two Increment Pouring	Notes	Wax Used in Comp B
H	1	20	173-178	75-78	0					Petrolite HOL-053-5095
H	2	20	175-180	73-79	40					Petrolite HOL-053-5095
H	3	19	175-178	72-75	0					Petrolite HOL-053-5095
I	1	10	175-177	78-81	0					Castor wax HOL-057-3
I	2	10	174-178	77-79	40					Castor Wax HOL-057-3
I	3	21	175-182	73-78	40					Castor wax HOL-057-3
I	4	10	175-177	74-75	0					Castor wax HOL-057-3
I	5	7	176-177	74-75	70					Castor wax HOL-057-3
J	1	4	175-176	71-72	0					Indramic wax
J	2	4	175-176	92-93	0					Indramic wax
J	3	4	187-189	90-94	0					Indramic wax
J	4	6	183-186	70-73	0					Indramic wax
J	5	4	180-184	81-83	40	3.5	2.5			Indramic wax
J	6	4	182	81-83	40	3.5	In-Out			Indramic wax
J	7	4	183-184	82-83	40	1.5	2.5			Indramic wax
J	8	4	184	83-84	0-40	1.5	In-Out			Indramic wax
J	9	4	181-183	82-83	40					Indramic wax
J	10	10	175-176	77-79	40					Indramic wax
J	11	4	174-175	90-95	40	3.5	2.5			Indramic wax
J	12	4	176-178	90-92	40	3.5	5.0			Indramic wax
J	13	2	175-177	90	40					Indramic wax
J	14	10	176-178	75-77	0					Indramic wax
J	15	10	175-178	75-78	70					Indramic wax
J	16	17	176-179	75-77	40					Indramic wax
J	17	5	179-181	75-78	40					Indramic wax
J	18	5	180	82-85	40					Indramic wax
J	19	6	182-184	76-78	40					Indramic wax
J	20	6	184-186	82-85	40					Indramic wax
J	21	11	177-180	76-80	70-100					Indramic wax
K	21	4	180	89-91	40	4	5			Indramix wax
K	22	4	179-180	89-90	40	4	15			Indramic wax
K	23	2	179-182	90	40					Indramic wax
L	1	3	179-180	90-91	40			yes	7	Indramic wax
L	2	3	180	90	40			yes	8	Indramic wax
L	3	3	180-182	90-91	40			yes	9	Indramic wax
M	1	4	179	82-83	40					Indramic wax
M	2	4	178-180	82-85	40				10	Indramic wax
M	3	2	180	86-89	40					Indramic wax
M	4	2	180	86	40				10	Indramic wax
M	5	2	183-184	83-84	40				10	Indramic wax
M	6	2	184	84	40				10	Indramic wax

Test Group	Test Number	Number of Skids	Material Temperature	Steel Temperature	Percent Scrap	Probe Depth	Probe Time	Two Increment Pouring	Notes	Wax Used in Comp B
N	1	19	175-177	74-76	0					Petrolite HOL-053-5137
O	1	4	180	80	0					Sunoco wax
O	2	4	179-180	90-95	0					Sunoco wax
O	3	4	184-185	90-96	0					Sunoco wax
O	4	4	182-184	80-81	0					Sunoco wax
P	1	5	176	75-76	0					Indramic with span HOL-057-2
P	2	5	176-177	85-86	0					Indramic with span HOL-057-2
P	3	5	184-185	84-85	0					Indramic with span HOL-057-2
P	4	5	184-185	75-76	0					Indramic with span HOL-057-2
Q	1	5	180-182	79-81	40				13	Petrolite
Q	2	5	179-180	81-82	40				11	Petrolite
Q	3	5	180-181	80-82	40					Petrolite
Q	4	10	175-177	79-81	40				11	Petrolite
Q	5	10	174-177	80-83	40				12	Petrolite
Q	6	5	179-182	85-86	40				11	Petrolite
Q	7	5	180-181	85-87	40				12	Petrolite
Q	8	5	180-181	85-86	40				11	Petrolite
Q	9	5	180-181	85-86	40				12	Petrolite
Q	10	5	180-182	84-87	40					Petrolite
Q	11	5	180-182	85-87	40				12	Petrolite
Q	12	5	180-181	84-86	40					Petrolite
Q	13	5	180-182	85-86	40				12	Petrolite
Q	14	10	176-177	70	40				12	Petrolite
Q	15	5	175-177	60-64	40					Petrolite
Q	16	10	176	70-76	40					Petrolite

NOTES:

1. Sorted low viscosity Composition B was used. The viscosity was 5 seconds or less. Lot HOL-053-5050.

2. First pour was 176°F with a second pour of 200°F. Height of first pour was to the top of the former.

3. First pour was 176°F with a second pour of 200°F. Height of first pour was 3/4 of the way up the former or 3 3/4 inches from the bottom of the riser.

4. The first increment was poured to 3 3/4 inches from the bottom of the riser. The second pour material temperature was 200°F.

5. There was no 5+1 minute delay between pouring and probing. These skids were probed as soon as they reached the cooling bay.

6. Sorted high viscosity Composition B was used. The viscosity of 6 seconds or higher.

7. One half of the explosive was poured in the first increment. There was a time delay of 1 minute between pours.

8. One half of the explosive was poured in the first increment. Then there was a time delay of 2 minutes between pours.

9. One half of the explosive was poured in the first increment. There was a time delay of 3 minutes between pours.

10. Fiber washers were placed between the riser and shell.

11. Canvas shroud was used.

12. Picatinny shroud without the baffle was used.

13. Picatinny shroud with modified baffle was used. The center section of the baffle was removed.

GROUP A - STRAIGHT POURING

Test #	Explosive Temperature, $^{\circ}F$*	Shell Temperature, $^{\circ}F$*
1	176	70
2	180	70
3	184	70
4	176	80
5	180	80
6	184	80
7	176	90
8	180	90
9	184	90
10	176	80
11	180	80

NOTES:

* Nominal Temperature - record the actual temperature.

1. The riser temperature will be the same as the shell temperature.

2. Tests 1 thru 9 will use all virgin material.
   Tests 10 and 11 will use 40% scrap.

3. Single pour all shells.

4. Shroud time 1.25 hours.

5. Cooling period 3.75 hours.

6. 100% X-ray all shells.

7. Use wood shroud.

8. Use Composition B containing Petrolite ES670 wax which has been sorted by viscosity. The maximum viscosity will be 5 seconds.

GROUP A DEFECT SUMMARY

Nominal Shell Temperature

Nominal Explosive Temperature in Riser

100% Virgin

	70°	80°	90°
176°	[1] 1M	[4] 3C 10M	[7] 10C 74M
180°	[2] 1C 1C	[5] 0	[8] 16C 91M
184°	[3] 3C 1M	[6] 1C 2M	[9] 5C 147M

40% Scrap

	70°	80°	90°
176°	--	[10] 1M	--
180°	--	[11] 3C 43M	--

GROUP A GRIDDING SUMMARY

Nominal Shell Temperature

Nominal Explosive Temperature in Riser		70°	80°	90°
100% Virgin	176°	[1] 14	[4] 293	[7] 1495
	180°	[2] 27	[5] 8	[8] 2141
	180°	[3] 126	[6] 83	[9] 2769
40% Scrap	176°	--	[10] 36	--
	180°	--	[11] 1234	--

TEST GROUP A

Test Number	1	1	1	1	
Date	8/27/73	8/27/73	8/27/73	8/27/73	
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	176	176	178	178	
Cup Temperature	178	178	179	179	
Material Temperature	174	173	172	174	
Shell Temperature	78	72	73	70	
Time Poured	9:18	9:23	9:30	9:35	
Duration of Pour	29	43	35	40	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe [illegible] Number	-	-	-	-	

TEST GROUP A

Test Number	1	1	1	1	
Date	8/27/73	8/27/73	8/27/73	8/27/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A					
B					
C					
D					
Bay	96	96	96	96	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	1	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	60	60	59	60	
Maximum Area of Cavity	0	0	14.0	0	
Average Area of Cavity	0	0	14.0	0	
Median Area of Cavity	-	-	-	-	
Total Area of Cavity	0	0	14.0	0	

TEST GROUP A

Test Number	2	2	2	2	
Date	8/28/73	8/28/73	8/28/73	8/28/73	
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	184	184	184	184	
Cup Temperature	184	184	184	184	
Material Temperature	180	180	179	180	
Shell Temperature	75	70	70	69	
Time Poured	8:38	8:42	8:47	8:53	
Duration of Pour	41	42	41	40	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	2	2	2	2	
Date	8/28/73	8/28/73	8/28/73	8/28/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	87	88	89	89	
B					
C	91	91	90	90	
D	89	38	89	88	
Bay	95	95	95	95	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	1	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	60	60	59	60	
Maximum Area of Cavity	0	0	26.5	0	
Average Area of Cavity	0	0	26.5	0	
Median Area of Cavity	-	-	-	-	
Total Area of Cavity	0	0	26.5	0	

TEST GROUP A

Test Number	3				
Date	8/29/73				
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	188	194	194	194	
Cup Temperature	188	188	188	190	
Material Temperature	182	183	185	185	
Shell Temperature	77	70	75	75	
Time Poured	9:44	9:54	10:02	10:07	
Duration of Pour	38	37	37	37	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	[illegible]	3	3	3	
Date	8/29/73	8/29/73	8/29/73	8/29/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A		90			
B		89			
C		90			
D		88			
Bay	96	95	96	97	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	2	1	0	
Number of Minors	0	1	0	0	
Number of Cavities	0	3	1	0	
Number of Good Shells	60	57	59	60	
Maximum Area of Cavity	0	34.5	37.5	0	
Average Area of Cavity	0	29	37.5	0	
Median Area of Cavity	-	24	-	-	
Total Area of Cavity	0	76	37.5	0	

TEST GROUP A

Test Number	4				
Date	8/27/73				
Skid Number	5	6	7	8	13

Multipour Data (First Pour)

Reservoir Temperature	177	176	176	176	178
Cup Temperature	178	178	178	178	178
Material Temperature	176	176	176	176	175
Shell Temperature	82	82	80	80	80-87
Time Poured	7 22	7:25	7 32	7:35	9:52
Duration of Pour	47	50	48	48	45
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP A

Test Number	4	-	-	4	4
Date	8/27/73	8 27/73	8/27/73	8/27/73	8/27/73
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	92	91	92	92	-
B	91	92	91	91	-
C	92	92	92	92	-
D	90	90	90	90	-
Bay	97	97	97	97	-

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	1	2	0	0
Number of Minors	8	1	0	1	0
Number of Cavities	11	2	3	1	0
Number of Good Shells	52	58	58	[illegible]	60
Maximum Area of Cavity	27.[illegible]	23.[illegible]	[illegible]	[illegible]	0
Average Area of Cavity	16.3	21.0	19.6	17.5	0
Median Area of Cavity	18.5		26.0		0
Total Area of Cavity	179.5	42.0	59.0	17.5	0

TEST GROUP A

Test Number	5	5	5	5	
Date	8/28/73	8/28/73	8/28/73	8/28/73	
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	182	182	180	182	
Cup Temperature	182	184	182	184	
Material Temperature	177	177	179	179	
Shell Temperature	80	82	80	81	
Time Poured	7:37	7:41	7:47	7:50	
Duration of Pour	42.5	44	45	45	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Proue Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	5	5	5	5	
Date	8/28/73	8/28/73	8/28/73	8/28/73	
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	89	89	89	89	
B					
C	91	92	92	91	
D	89	89	89	88	
Bay	96	96	98	97	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	2	1	1	
Number of Good Shells	60	60	60	60	
Maximum Area of Cavity	0	2.0	3.0	2.0	
Average Area of Cavity	0	1.5	3.0	2.0	
Median Area of Cavity	-	-	-	-	
Total Area of Cavity	0	3.0	3.0	2.0	

TEST GROUP A

Test Number	6				
Date	8/29/73				
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	192	194	194	194	
Cup Temperature	186	186	186	186	
Material Temperature	181	183	185	184	
Shell Temperature	80	80	80	80	
Time Poured	7:45	7:51	7:59	8:04	
Duration of Pour	50	38	35	34	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	6	6	6	6	
Date	8/29/73	8/29/73	8/29/73	8/29/73	
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	97	94	
Cooling Bay Temp. Averages					
A	92	92	92	92	
B	91	91	91	91	
C	92	92	92	92	
D	90	90	90	90	
Bay	97	97	96	96	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	1	0	
Number of Minors	1	0	1	0	
Number of Cavities	1	0	2	0	
Number of Good Shells	59	60	58	60	
Maximum Area of Cavity	24.5	0	32.0	0	
Average Area of Cavity	24.5	0	32:5	0	
Median Area of Cavity	-	-	-	0	
Total Area of Cavity	24 5	0	57.5	0	

TEST GROUP A

Test Number	7				
Date	8/27/73				
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	179	177	179	179	
Cup Temperature	179	178	179	179	
Material Temperature	176	176	176	176	
Shell Temperature	90	90	93	90	
Time Poured	6:50	6:52	6:58	7:01	
Duration of Pour	53	-	-	47	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	7	7	7	7	
Date	8/27/73	8/27/73	8/27/73	8/27/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	91	91	91	91	
B	90	90	90	90	
C	91	91	91	91	
D	90	90	90	90	
Bay	97	97	96	96	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	1	0	6	3	
Number of Minors	13	12	2	40	
Number of Cavities	15	13	17	46	
Number of Good Shells	46	48	45	17	
Maximum Area of Cavity	32.5	27.5	25.5	25.5	
Average Area of Cavity	17.6	18.7	18.4	16.4	
Median Area of Cavity	19.0	17.5	18.0	16.5	
Total Area of Cavity	264.0	244.0	313.0	674.0	

TEST GROUP A

Test Number	8	8	8	8	
Date	8/28/73	8/28/73	8/28/73	8/28/73	
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	186	186	184	184	
Cup Temperature	184	182	182	182	
Material Temperature	182	180	182	180	
Shell Temperature	92	92	91	90	
Time Poured	6:46	6:51	6:54	6:59	
Duration of Pour	36	35	37	40	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	8	8	8	8	
Date	8/28/73	8/28/73	8/28/73	8/28/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	90	90	90	90	
B					
C	92	90	89	92	
D	90	90	90	90	
Bay	97	97	97	97	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	12	2	1	1	
Number of Minors	30	38	11	12	
Number of Cavities	47	44	16	16	
Number of Good Shells	18	20	48	47	
Maximum Area of Cavity	31.0	35.5	23.5	34.0	
Average Area of Cavity	19.1	19.8	14.9	14.0	
Median Area of Cavity	19.0	19.0	16.5	14.5	
Total Area of Cavity	862.5	871.5	224.5	182.0	

TEST GROUP A

Test Number	9				
Date	8/29/73				
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	190	190	190	190	
Cup Temperature	186	186	186	186	
Material Temperature	183	183	184	183	
Shell Temperature	92	92	92	93	
Time Poured	6:52	6:59	7:03	7:08	
Duration of Pour	37	35	33	35	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	--	

TEST GROUP A

Test Number	9	9	9	9	
Date	8/29/73	8/29/73	8/29/73	8/29/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	92	92	92	91	
B	91	91	91	91	
C	92	92	93	92	
D	91	91	91	91	
Bay	97	97	97	97	

X-Ray Results

Number of Shells Poured	58*	60	60	60	
Number of Criticals	2	0	3	0	
Number of Minors	28	42	31	46	
Number of Cavities	35	46	37	53	
Number of Good Shells	28	18	26	14	
Maximum Area of Cavity	33.0	22.0	37.5	41.0	
Average Area of Cavity	19.4	15.2	23.2	19.2	
Median Area of Cavity	20.5	16.0	23.5	19.0	
Total Area of Cavity	734.5	213.5	860.0	961.0	

*Deleted shells #5 and #59 as the explosive level was too low to produce a good shell.

TEST GROUP A

Test Number	10	10	10	10	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	
Cup Temperature	180	180	179	179	
Material Temperature	176	176	176	176	
Shell Temperature	80	80	78	82	
Time Poured	7:07	7:18	7:28	7:32	
Duration of Pour	47	43	41	41	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	10	10	10	10	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	89	89	89	89	
B	89	89	89	89	
C	89	90	89	89	
D	87	87	87	86	
Bay	94	94	94	94	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

TEST GROUP A

Test Number	10	10	10	10	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	178	180	186	190	
Cup Temperature	179	180	180	180	
Material Temperature	173	174	174	175	
Shell Temperature	85	78	77	80	
Time Poured	7:39	7:44	7:49	7:56	
Duration of Pour	44	43	47	40	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
C Temperature	-	-	-	-	
terial Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	--	

TEST GROUP A

Test Number	10	10	10	10	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	89	89	89	89	
B	89	89	89	89	
C	89	89	89	90	
D	86	86	87	87	
Bay	94	94	94	94	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	1	0	0	0	
Number of Cavities	1	0	0	0	
Number of Good Shells	59	60	60	60	
Maximum Area of Cavity	36.5	0	0	0	
Average Area of Cavity	36.5	0	0	0	
Median Area of Cavity	-	-	-	-	
Total Area of Cavity	36.5	0	0	0	

TEST GROUP A

Test Number	11	11	11	11	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	184	184	184	188	
Cup Temperature	182	182	182	130	
Material Temperature	180	180	180	180	
Shell Temperature	82	84	84	83	
Time Poured	8:44	8:47	8:52	9:20	
Duration of Pour	36	40	-	35	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	11	11	11	11	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	87	87	87	87	
B	87	87	87	88	
C	87	87	87	87	
D	85	85	85	85	
Bay	92	92	92	92	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	1	
Number of Minors	14	14	0	0	
Number of Cavities	19	17	0	6	
Number of Good Shells	46	46	60	59	
Maximum Area of Cavity	37.5	20.5	0	29.0	
Average Area of Cavity	19.2	20.6 0	14.2		
Median Area of Cavity	19.5	23.0	-	13.0	
Total Area of Cavity	364.5	351.5	0	85.0	

TEST GROUP A

Test Number	11	11	11	11	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	11	14	15	16	

Multipour Data (First Pour)

Reservoir Temperature	186	186	185	185	
Cup Temperature	180	180	181	181	
Material Temperature	180	180	180	182	
Shell Temperature	84	85	84	83	
Time Poured	9:23	9:27	9:31	9:36	
Duration of Pour	37	3[illegible]	35	-	
Multipour Number	2	[illegible]	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP A

Test Number	11	11	11	11	
Date	8/30/73	8/30/73	8/30/73	8/30/73	
Skid Number	13	14	15	16	

Cooling Bay Data

Cooling Bay - Position	3-13	3-14	2-9	2-10	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A			-	-	
B			-	-	
C			-	-	
D			-	-	
Bay	93	94	90	90	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	2	
Number of Minors	2	7	0	4	
Number of Cavities	2	9	0	8	
Number of Good Shells	58	53	60	52	
Maximum Area of Cavity	22.5	32.5	0	34.5	
Average Area of Cavity	17.5	21.8	0	25.2	
Median Area of Cavity	-	26.5	-	28.5	
Total Area of Cavity	35.0	196.0	0	202.0	

TEST GROUP B

PURPOSE

The purpose of this group was to run a variable study on hot topping. The general objective of hot topping is to create a hotter reservoir of material in the funnel section so as to prolong the time before the former section freezes over.

PROCEDURE

There were two variables; the explosive temperature for the first pour at 176° and 184°F; and the height of the first pour at the top of the former and at 3/4 up the former (3 1/2 inches from the break off). All hot top offs were targeted for 200°F, with an approximate 1 minute delay between pours. All shells were targeted for 80°F and cooling bays were at a high temperature.

Comp B with Petrolite ES 670,Lot 053-5050, was used with scrap incorporated at 40%.

For each test, four skids, or 240 shells, were poured. The insulated, wooden shroud was used for all skids.

The X-rays were gridded in a similar manner to those for Group A.

DISCUSSION

GROUP B TWO INCREMENT POURING

Test #	1st Increment	2nd Increment	Height of First Pour
1	176	200	Top of former
2	176	200	3/4 way up former
3	184	200	Top of former
4	184	200	3/4 way up former

NOTES:

1. Shell and funnel temperature 80°F nominal - record actual temperature.

2. The maximum time between pours was 1 minute.

3. Composition B containing Petrolite ES670 wax with 40% riser scrap.

4. Four skids per test.

GROUP B TWO INCREMENT POURING DEFECT SUMMARY

Height of First Pour	Explosive Temperature 176°/200°	Explosive Temperature 184°/200°
Top of Former	1: 4C	3: 0
3/4 of Former	2: 1M*	4: 0

*See discussion for explanation of minor defect.

GROUP B TWO INCREMENT POURING
GRIDDING SUMMARY

Height of First Pour	Explosive Temperature 176°/200°	Explosive Temperature 184°/200°
Top of Former	1 — 129.5	3 — 0
3/4 Up Former	2 — 27.5*	4 — 0

*See discussion for explanation of minor defect.

TEST GROUP B

Test Number	1	1	1	1	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	174	174	172	172	
Cup Temperature	176	174	174	174	
Material Temperature	178	177	176	176	
Shell Temperature	84	84	82	80	
Time Poured	7:57	8:01	8:04	8:09	
Duration of Pour	33	33	33	-	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	198	200	200	
Cup Temperature	-	198	198	198	
Material Temperature	194	195	198	198	
Time Poured		7:04	8.02	8:10	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP B

Test Number	1	1	1	1	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	85	85	85	85	
B	86	86	86	86	
C	86	86	86	86	
D	85	85	85	85	
Bay	88	88	88	88	

X-Ray Results

Number of Shells Poured	59*	60	60	60	
Number of Criticals	2	1	0	1	
Number of Minors	0	0	0	0	
Number of Cavities	5	3	0	1	
Number of Good Shells	57	59	60	59	
Maximum Area of Cavity	26.5	15	0	-	
Average Area of Cavity	11.4	15.2	0	-	
Median Area of Cavity	6.5	6.5	0	-	
Total Area of Cavity	58.0	45.5	0	26.0	

*Shell 46 omitted.

TEST GROUP B

Test Number	2	2	2	2	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	13	14	15	16	

Multipour Data (First Pour)

Reservoir Temperature	174	175	173	174	
Cup Temperature	180	181	182	180	
Material Temperature	178	184	178	178	
Shell Temperature	80	80	80	80	
Time Poured	11:01	11:04	11:09	11:11	
Duration of Pour	40	34	34	34	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	199	199	198	198	
Cup Temperature	198	198	198	198	
Material Temperature	198	194	194	194	
Time Poured	11.05	11:06	11:11	11:13	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP B

Test Number	2	2	2	2	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	13	14	15	16	

Cooling Bay Data

Cooling Bay - Position	3-13	2-8	2-9	2-10	
Length of Shroud Time	75	79	75	75	
Cooling Bay Temp. Averages					
A	86	85	85	85	
B	87	-	-	-	
C	86	-	-	-	
D	84	-	-	-	
Bay	89	85	85	85	

X-Ray Results

Number of Shells Poured	18*	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	1	0	0	0	
Number of Cavities	1	0	0	0	
Number of Good Shells	17	60	60	60	
Maximum Area of Cavity	-	0	0	0	
Average Area of Cavity	-	0	0	0	
Median Area of Cavity	-	0	0	0	
Total Area of Cavity	27.5	0	0	0	

*Most of the shells were poured too low.

TEST GROUP B

Test Number	3	3	3	3	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	182	182	182	182	
Cup Temperature	184	184	184	183	
Material Temperature	185	184	184	183	
Shell Temperature	80	80	80	80	
Time Poured	9:03	9:12	9:15	9:19	
Duration of Pour	35	30	34	32	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	201	201	200	200	
Cup Temperature	200	200	200	200	
Material Temperature	198	198	192	193	
Time Poured	9:09	9:13	9:16	9:20	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP B

Test Number	3	3	3	3	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	85	85	85	86	
B	86	86	86	86	
C	86	86	86	86	
D	85	84	84	84	
Bay	88	88	88	88	

X-Ray Results

Number of Shells Poured	59*	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	59	60	60	60	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

*Shell 3 omitted as it was poured too low to produce a good shell.

TEST GROUP B

Test Number	4	4	4	4	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	186	186	186	186	
Cup Temperature	185	184	184	184	
Material Temperature	184	184	184	184	
Shell Temperature	80	82	-	82	
Time Poured	10:02	10:10	10:12	10:14	
Duration of Pour	-	29	30	30	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	198	198	198	188	
Cup Temperature	198	197	197	187	
Material Temperature	-	200	200	200	
Time Poured	10:09	10:12	10:13	10:15	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP B

Test Number	4	4	4	4	
Date	9/4/73	9/4/73	9/4/73	9/4/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	85	85	84	85	
B	85	85	85	85	
C	86	86	86	86	
D	85	85	85	85	
Bay	89	89	89	89	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0		
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

GROUP C PROBING

Test #	Explosive Temperature	Time Duration of Probe, Min.
1	176	5
2	180	5
3	176	2.5
4	180	2.5
5	176/200	5
6	176/200	2.5
7	176/200	In-Out

NOTES:

1. The maximum probe pressure was 10 psig.
2. Depth of probe was 1 to 2 inches above the break-off point.
3. Shell temperature was $80^{o}F \pm 2^{o}F$ record actual temperature.
4. Time to start probing was 5+1 minutes after first pouring.
5. Four skids per test.
6. Composition B containing Petrolite ES670 wax with 40% riser scrap was used.

GROUP C PROBING GRIDDING SUMMARY

Probe Time

	5 minutes	2.5 minutes	10-15 seconds
176°	1 0	3 0	-
180°	2 330	4 0	-
176°/200°	5 0	6 60	7 62

GROUP C PROBING DEFECT SUMMARY

Probe Time

	5 minutes	2.5 minutes	10-15 sec
176°	1 0	3 0	-
180°	2 1C 15M	4 0	-
$176^{\circ}/200^{\circ}$	5 0	6 1C 1M	7 1C

TEST GROUP C

Test Number	1	1	1	1	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	174	175	176	178	
Cup Temperature	182	182	180	178	
Material Temperature	176	177	178	177	
Shell Temperature	80	79	82	82	
Time Poured	7:07	7:11	7:22	7:27	
Duration of Pour	45	34	41	45	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7:13	7:16:30	7:27	7:32	
Time Probe Down	-	7:16:36		7:32:07	
Time Finish	7:18	7:21:30	7:32	7:37:04	
Duration of Pour	-	-	-	-	
Probe Temperature	220	-	220	230	
Probe Unit Number	-	-	-	-	

TEST GROUP C

Test Number	1	1	1	1	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	4-1	3-1	4-2	3-2	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	86	85	85	85	
B	-	85	-	84	
C	-	85	-	84	
D	-	87	-	86	
Bay	89	89	89	88	

X-Ray Results

Number of Shells Poured	60	59*	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	59	60	60	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

*Shell #20 omitted as it was poured too low to produce a good shell.

TEST GROUP C

Test Number	2	2	2	2	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	13	14	15	16	

Multipour Data (First Pour)

Reservoir Temperature	182	184	183	183	
Cup Temperature	182	180	181	182	
Material Temperature	180	183	184	186	
Shell Temperature	79	80	80	80	
Time Poured	9:13	9:31	9:36	9:39	
Duration of Pour	37	35	40	37	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	9:18:30	9:36:04	9:41	9:44	
Time Probe Down	-	9:36:12	-	9:44:09	
Time Finish	9:23:30	9:41:04	9:46	9:49	
Duration of Pour	-	-	-	-	
Probe Temperature	220	-	220	230	
Probe Unit Number	-	-	-	-	

TEST GROUP C

Test Number	2	2	2	2	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	13	14	15	16	

Cooling Bay Data

Cooling Bay - Position	4-7	3-12	4-8	4-	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	84	85	86	84	
B	-	84	-	84	
C	-	84	-	84	
D	-	85	-	85	
Bay	88	88	86	88	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	1	0	
Number of Minors	0	7	2	6	
Number of Cavities	0	7	3	7	
Number of Good Shells	60	53	57	54	
Maximum Area of Cavity	0	31.5	42	27.5	
Average Area of Cavity	0	18	29.5	19.25	
Median Area of Cavity	0	19.5	27.5	19.5	
Total Area of Cavity	0	126	88.5	115.5	

TEST GROUP C

Test Number	3	3	3	3	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	178	179	179	178	
Cup Temperature	177	177	178	178	
Material Temperature	176	177	176	177	
Shell Temperature	80	82	80	80	
Time Poured	7:34	7:39	7:43	7:50	
Duration of Pour	43	45	43	43	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7:39	7:44:08	7:48	7:55:06	
Time Probe Down	-	7:44:16	-	7:55:10	
Time Finish	7:41:30	7.46:46	7:50:30	7:57:35	
Duration of Pour	-	-	-	-	
Probe Temperature	220	234	220	-	
Probe Unit Number	-	-	-	-	

TEST GROUP C

Test Number	3	3	3	3	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	4-3	3-3	4-4	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	85	85	85	85	
B	-	85	-	85	
C	-	84	-	84	
D	-	87	-	86	
Bay	89	88	89	88	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

TEST GROUP C

Test Number	4	4	4	4	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	180	184	184	182	
Cup Temperature	182	182	182	181	
Material Temperature	178	179	180	180	
Shell Temperature	80	77	80	80	
Time Poured	8:47	9:52	8:59	9:03	
Duration of Pour	44	41	41	39	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7:52	9:57:03	9:04	9:08:03	
Time Probe Down	-	9:57:10	-	9:08:10	
Time Finish	7:54:30	9:59:45	9:06:30	9:10:33	
Duration of Pour	-	-	-	-	
Probe Temperature	220	230	220	-	
Probe Unit Number	-	-	-	-	

TEST GROUP C

Test Number	4	4	4	4	
Date	9/5/73	9/5/73	9/5/73	9/5/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	4-5	3-10	4-6	3-6	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	84	84	84	84	
B	-	84	-	83	
C	-	84	-	83	
D	-	84	-	84	
Bay	88	88	88	87	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

TEST GROUP C

Test Number	5	5	5	5	
Date	9/6/73	9/6/73	9/6/73	9/6/73	
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	178	174	176	174	
Cup Temperature	179	181	180	180	
Material Temperature	176	176	176	177	
Shell Temperature	81	81	81	81	
Time Poured	6:30	6:47	6:51	6:55	
Duration of Pour	35	34	34	34	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	200	196	196	196	
Cup Temperature	196	198	198	198	
Material Temperature	202	200	199	200	
Time Poured	-	6:49	6:53	6:59	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	6:35	6:54:00	6:56	7:04:3	
Time Probe Down	-	6:54:02	-	7:04:3	
Time Finish	6:40	6:59	7:01	7:09:0	
Duration of Pour	-	-	-	-	
Probe Temperature	220	230	220	225	
Probe Unit Number	4	3	4	3	

TEST GROUP C

Test Number	5	5	5	5	
Date	9/6/73	9/6/73	9/6/73	9/6/73	
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	86	87	86	86	
B	96	96	96	96	
C	84	84	84	84	
D	86	86	86	86	
Bay	90	90	90	90	

X-Ray Results

Number of Shells Poured	60	60	60	59*	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	59	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	0	

*Shell 55 omitted as it was poured too low to produce a good shell.

TEST GROUP C

Test Number	6	6	6	6	
Date	9/6/73	9/6/73	9/6/73	9/6/73	
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	
Cup Temperature	177	178	178	178	
Material Temperature	177	177	177	178	
Shell Temperature	80	80	81		
Time Poured	7:08	7:12	7:18	7:22	
Duration of Pour	33	33	34	34	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	196	196	196	197	
Cup Temperature	199	199	199	199	
Material Temperature	197	197	195	191	
Time Poured	7:10	7:13	7:19	7:23	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	7:15	7:18:10	7:24	7:29	
Time Probe Down	-	7:18:16	-	-	
Time Finish	7:17:30	7:20:40	7:26:30	7:31:30	
Duration of Pour	220	229	220	227	
Probe Temperature	4	3	4	3	
Probe Unit Number					

TEST GROUP C

Test Number	6	6	6	6	
Date	9/6/73	9/6/73	9/6/73	9/6/73	
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-8	3-9	3-	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	86	86	86	87	
B	86	86	86	86	
C	83	85	85	84	
D	86	86	86	85	
Bay	90	90	90	90	

X-Ray Results

Number of Shells Poured	59***	60	57*	58**	
Number of Criticals	1	0	0	0	
Number of Minors	0	1	0	0	
Number of Cavities	2	1	0	0	
Number of Good Shells	58	59	57	58	
Maximum Area of Cavity	49.5	20.5	0	0	
Average Area of Cavity	49.5	20.5	0	0	
Median Area of Cavity	-	-	0	0	
Total Area of Cavity	49.5	20.5	0	0	

*Shells 2, 3, and 13 are omitted as they were poured too low to produce a good shell.
**Shells 2 and 3 are omitted as they were poured too low to produce a good shell.
***Shell 7 omitted. Low pour.

TEST GROUP C

Test Number	7	7	7	7	
Date	9/6/73	9/6/73	9/6/73	9/6/73	
Skid Number	9	10	11	12	

Multipour Data (First Pour)

Reservoir Temperature	174	174	174	174	
Cup Temperature	178	178	178	178	
Material Temperature	176	177	177	178	
Shell Temperature	80	80	80	80	
Time Poured	8:23	8:25	8:28	8:33	
Duration of Pour	34	34	34	34	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	200	200	200	200	
Cup Temperature	199	199	199	199	
Material Temperature	195	195	195	198	
Time Poured	8:24	8:26	8:29	8:34	
Duration of Pour	-	-	-	-	
Multipour Number	1	1	1	1	

Core Melting Data

Time Start	8:29	8:31	8:34	8:39	
Time Probe Down	-	-	-	-	
Time Finish	8:29:14	8:31:12	8:34:11	8:39:11	
Duration of Pour	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	4	4	4	4	

TEST GROUP C

Test Number	7	7	7	7	
Date	9/6/73	9/6/73	9/6/73	9/6/73	
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	4-	4-	4-	3-6	
Length of Shroud Time	75	75	75	75	
Cooling Bay Temp. Averages					
A	85	85	85	85	
B	84	84	84	84	
C	83	83	83	83	
D	84	84	84	84	
Bay	88	88	90	89	

X-Ray Results

Number of Shells Poured	57*	58 **	60	60	
Number of Criticals	1	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	1	0	0	0	
Number of Good Shells	56	58	60	60	
Maximum Area of Cavity	-	0	0	0	
Average Area of Cavity	-	0	0	0	
Median Area of Cavity	-	0	-	-	
Total Area of Cavity	62	0	0	0	

*Shells 2, 5, and 6 omitted. Low pour.
**Shells 2, 13 omitted. Low pour.

GROUP D PETROLITE WITH 0.1% SPAN 85

Test #	Percent Scrap	Probe
1	0	No
2	40	No
3	40	2.5 minutes
4	0	2.5 minutes
5	70	2.5 minutes

NOTES:

1. Single pour.
2. Material temperature $176^{\circ} \pm 2^{\circ}F$.
3. Shell temperature $75^{\circ} \pm 5^{\circ}F$.
4. Core melt to depth of 1 to 2 inches above the break-off point. Start probing at 5+1 minutes after pouring and probe for 2.5 minutes.
5. Shroud time 1.25 hours.
6. Cooling period 3.75 hours.
7. 100% X-ray all shells.
8. Use wood shroud.
9. 10 skids per test except Test #1 which was 20 skids.

GROUP D DEFECT SUMMARY

% Scrap	Probe Time: No Probe	Probe Time: 2.5 Minutes
0	1 — 4C 1M	4 — 2C 2M
40	2 — 0	3 — 1M
70	-	5 — 1M

Table 1 Group D Defect Summary

Test Group D

Test Number	1	1	1	1	1
Date	9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	176	175	174	174	176
Cup Temperature	176	176	176	176	176
Material Temperature	177	176	174	176	176
Shell Temperature	78	77	77	76	76
Time Poured	5:58	6:01	6:06	6:10	6:38
Duration of Pour	43	35	45	50	45
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Melt Number	-	-	-	-	-

Test Group D

Test Number	1	1	1	1	1
Date	9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	1	2	3	4	5

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	81	81	81	81	81
B	81	81	81	81	81
C	81	81	81	81	81
D	82	82	82	81	81
Bay	83	83	83	83	82

X-Ray Results

Number of Shells Poured	59A	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	4	0	0
Number of Good Shells	59	60	60	60	60
Maximum Area of Cavity	0	0	5	0	7.5
Average Area of Cavity	0	0	4.5	0	7
Median Area of Cavity	0	0	0	0	0
Total Area of Cavity	0	0	18	0	14

A Shell 37 omitted.

Test Group D

Test Number	1	1	1	1	1
Date	9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	176	174	174	173	172
Cup Temperature	176	176	176	176	176
Material Temperature	176	176	175	176	175
Shell Temperature	75	77	77	77	75
Time Poured	6:42	6:46	6:49	7:00	7:04
Duration of Pour	45	45	43	44	44
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

Test Group D

Test Number	1	1	1	1	1
Date	9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	81	81	81	80	80
B	81	81	81	80	80
C	81	81	81	80	80
D	81	81	81	82	82
Bay	82	82	82	84	84

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	0	0	0	1
Number of Minors	0	0	0	0	0
Number of Cavities	1	0	0	1	1
Number of Good Shells	59	60	60	60	60
Maximum Area of Cavity	-	0	0	-	-
Average Area of Cavity	-	0	0	-	-
Median Area of Cavity	-	0	0	-	-
Total Area of Cavity	34	0	0	7.5	24.5

Test Group D

Test Number	1	1	1	1	1
Date	9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	171	171	171	171	172
Cup Temperature	176	176	176	176	177
Material Temperature	177	177	177	176	176
Shell Temperature	77	77	75	78	76
Time Poured	7:17	7:21	7:25	7:30	7:33
Duration of Pour	44	45	42	42	44
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature				-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

Test Group D

Test Number	1	1	1	1	1
Date	9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	80	80	80	80	79
B	80	80	80	80	
C	80	80	80	80	
D	80	80	81	81	
Bay	83	83	83	83	82

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	0	1	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	1	0	1	0	0
Number of Good Shells	59	60	59	60	50
Maximum Area of Cavity	-	0	-	0	0
Average Area of Cavity	-	0	-	0	0
Median Area of Cavity	-	0	-	0	0
Total Area of Cavity	31.5	0	25	0	0

TEST GROUP D

Test Number	1	1	1	1	1
Date	9/10/73	9/10/73	9/10/73	9/10/73	9/10/73
Skid Number	17	18	19	20	21

Multipour Data (First Pour)

Reservoir Temperature	172	172	172	172	172
Cup Temperature	176	176	176	176	176
Material Temperature	176	176	178	177	177
Shell Temperature	76	75	75	74	76
Time Poured	8:22	8:25	8:28	8:31	8:35
Duration of Pour	42	43	42	44	44
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP D

Test Number	1	1	1	1	1
Date	9/10/73	9/10/73	9/10/73	9/10/73	9/10/73
Skid Number	17	18	19	20	21

Cooling Bay Data

Cooling Bay - Position	4-3	4-4	4-5	4-6	4-7
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	80	80	80	80	
B	-	-	-	-	-
C	-	-	-	-	-
D	-	-	-	-	-
Bay	82	82	82	82	83

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	1	0	0	0
Number of Cavities	0	1	0	0	0
Number of Good Shells	60	59	60	60	60
Maximum Area of Cavity	0	-	0	0	0
Average Area of Cavity	0	-	0	0	0
Median Area of Cavity	0	-	0	0	0
Total Area of Cavity	0	12.5	0	0	0

Test Group D

Test Number	2	2	2	2	2
Date	9-11-73	9-11-73	9-11-73	9-11-73	9-11-73
Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	175	175	174	174	174
Cup Temperature	179	179	178	179	179
Material Temperature	176	178	178	177	177
Shell Temperature	78	76	79	76	77
Time Poured	5:38	5:42	5:45	6:00	6:12
Duration of Pour	42	36	40	37	36
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Pour	-	-		-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP D

Test Number	2	2	2	2	2
Date	9/11/73	9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	1	2	3	4	5

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-8
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	83	83	83	84	84
B	84	84	84	84	84
C	82	82	82	83	83
D	84	84	84	84	84
Bay	86	86	86	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

Test Group D

Test Number	2	2	2	2	2
Date	9-11-73	9-11-73	9-11-73	9-11-73	9-11-73
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	174	174	174	176	176
Cup Temperature	179	177	176	176	176
Material Temperature	177	177	176	176	176
Shell Temperature	75	78	77	77	77
Time Poured	6:16	6:20	6:23	6:57	7:01
Duration of Pour	37	37	37	40	38
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP D

Test Number	2	2	2	2	2
Date	9/11/73	9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	4-1	4-2
Length of Shroud Time	75	75	75	75	[illegible]
Cooling Bay Temp. Averages					
A	83	83	83	81	81
B	83	83	83		
C	82	82	82		
D	84	84	84		
Bay	86	86	86	85	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

NOTES:
1. On Skid 10 the crystallization and porosity was heavier than in the previous skids of this test, and had some small stringers.
2. Skid had very heavy porosity and crystallization with some small stringers under the fuze well.

TEST GROUP D

Test Number	3	3	3	3	3
Date	9/11/73	9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	176	176	176	176	176
Shell Temperature	77	77	78	78	77
Time Poured	7:04	7:09	7.17	7:23	7:40
Duration of Pour	39	36	37	35	37
Multipour Number	2	2	2	2	-

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	7:09	7:14:15	7:22	7:28	9:45
Time Probe Down	7:09:08	-	7:22:07	-	9:45:06
Time Finish	7:11:30	7:16:45	7:24:30	7:30:30	9:47:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	223	-	225	220±5	227
Probe Unit Number	3	4	3	4	3

TEST GROUP D

Test Number	3	3	3	3	3
Date	9/11/73	9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	3-12	4-3	3-13	4-4	3-14
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	82	81	82	81	81
B	83	-	83	-	82
C	82	-	82	-	82
D	83	-	83	-	82
Bay	88	85	88	85	83

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP D

Test Number	3	3	3	3	3
Date	9/11/73	9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	176	177	177	176	176
Shell Temperature	76	76	75	76	75
Time Poured	7:44	7:49	7:52	7:57	8:02
Duration of Pour	37	34	35	43	35
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	7:49	7:54	7:57	8:02	8:07
Time Probe Down	-	7:54:05	-	-	-
Time Finish	7:51:30	7:56:30	7:59:30	8:05:30	8:09:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	-	-	-	-	-
Probe Unit Number	4	3	4	3	4

TEST GROUP D

Test Number	3	3	3	3	3
Date	9/11/73	9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	16	17	18	19	20

Cooling Bay Data

Cooling Bay - Position	4-5	3-5	4-6	3-6	4-7
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	81	82	80	81	80
B	-	81	-	81	-
C	-	80	-	80	-
D	-	82	-	82	-
Bay	84	85	84	85	83

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	1	0	0
Number of Cavities	0	0	1	0	0
Number of Good Shells	60	60	59	60	60

TEST GROUP D

Test Number	4	4	4	4	4
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	174	174	175	174	174
Cup Temperature	180	179	179	180	180
Material Temperature	176	177	176	176	177
Shell Temperature	78	79	79	79	78
Time Poured	5:48	5:52	5:55	6:00	6:03
Duration of Pour	41	41	42	44	41
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	5:53:00	5:57	6:00	6:05	6:08
Time Probe Down	-	-	-	-	-
Time Finish	5:55:30	5:59:30	6:02:30	6:07:30	6:10:00
Duration of Probe	2.5	2.5	2.5	2.5	2.0
Probe Temperature	221	-	221	-	-
Probe Unit Number	3	4	3	4	3

TEST GROUP D

Test Number	4	4	4	4	4
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	1	2	3	4	5

Cooling Bay Data

Cooling Bay - Position	3-1	4-12	3-2	4-1	4-2
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	84	84	84	84	84
B	83	-	83	-	-
C	83	-	82	-	-
D	83	-	85	-	-
Bay	87	87	87	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	1	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	1	0
Number of Good Shells	60	60	60	59	60

TEST GROUP D

Test Number	4	4	4	4	4
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	175	175	174	175	174
Cup Temperature	180	180	180	180	180
Material Temperature	177	177	177	177	178
Shell Temperature	79	79	79	79	77
Time Poured	6:07	6:11	6:15	6:19	6:23
Duration of Pour	37	38	38	37	38
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	6:12	6:16:00	6:20	6:24	6:28
Time Probe Down	-	-	-	-	-
Time Finish	6:14:30	6:18:30	6:22:30	6:26:30	6:30:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	-	-	-	-	-
Probe Unit Number	4	3	4	3	4

TEST GROUP D

Test Number	4	4	4	4	4
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	4-3	3-3	4-4	3-4	4-5
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	84	84	84	84	84
B	-	83	-	83	-
C	-	82	-	82	-
D	-	8	-	85	-
Bay	87	87	87	87	86

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	1	0	0	0
Number of Minors	0	0	1	1	0
Number of Cavities	0	1	1	1	0
Number of Good Shells	60	59	59	59	60

TEST GROUP D

Test Number	5	5	5	5	5
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	172	174	172	172	180
Cup Temperature	182	182	182	182	179
Material Temperature	176	176	176	178	176
Shell Temperature	77	75	76	76	74
Time Poured	7:08	7:12	7:16	7:20	7:34
Duration of Pour	40	39	34	33	38
Multipour Number	1	1	1	1	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	7:13	7:17	7:21	7:25	7:39
Time Probe Down	-	-	-	-	
Time Finish	7:15	7:19:30	7:23:30	7:27:30	7:41:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	-	-	-	-	
Probe Unit Number	3	4	3	4	

TEST GROUP D

Test Number	5	5	5	5	5
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	3-14	4-11	3-13	4-6	3-12
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	82	82	82	82	83
B	82	-	82	-	82
C	81	-	81	-	81
D	83	-	83	-	83
Bay	86	86	86	86	86

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP D

Test Number	5	5	5	5	5
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	176	175	173	172	172
Cup Temperature	178	178	180	180	180
Material Temperature	176	176	177	177	178
Shell Temperature	77	77	79	74	75
Time Poured	7:38	7·43	8·02	8 06	8·11
Duration of Pour	37	38	38	37	35
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	7:43	7.48	8:07	8:11	8:16
Time Probe Down	-	-	-	-	
Time Finish	7:45:30	7:50:30	8:09:30	8:13:30	8·18·30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	-	-	-	-	-
Probe Unit Number	4	3	4	3	4

TEST GROUP D

Test Number	5	5	5	5	5
Date	9/12/73	9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	16	17	18	19	20

Cooling Bay Data

Cooling Bay - Position	4-7	3-11	4-13	3-10	4-10
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	82	83	83	82	81
B	-	82	-	81	-
C	-	81	-	81	-
D	-	83	-	82	-
Bay	85	86	82	85	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

GROUP E PETROLITE

Test #	Number of Skids	Material Temperature	Steel Temperature	Percent Scrap	Nominal Probe Time Minutes
1	11	175-177	75-78	0	0
2	10	175-178	75-78	0	2.5
3	10	175-176	70-71	40	0
4	11	175-177	68-74	40	2.5
5	10	175-179	72-75	0	0
6	12	175-178	72-75	70	0

NOTES

1. Single pour.

2. The core melt depth was 1 to 2 inches above the break-off point. Probing was started 5+1 minutes after pouring.

3. Shroud time was 1.25 hours.

4. The total cooling period was 3.75 hours.

5. The Picatinny shroud and baffle were used.

GROUP E DEFECT SUMMARY

% Scrap	Probe: No	Probe: 2.5 minutes
0	[1,5] 0	[2] 0
40	[3] 0	[4] 0
70	[6] 0	-

TEST GROUP E

Test Number	1	1	1	1	1
Date	9-13-73	9-13-73	9-13-73	9-13-73	9-13-73
Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	174	174	174	174	175
Cup Temperature	176	178	178	179	179
Material Temperature	175	175	175	175	176
Shell Temperature	75	-	76	76	76
Time Poured	5:18	5:29	5:32	5:35	5:35
Duration of Pour	-	45	45	45	43
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP E

Test Number	1	1	1	1	1
Date	9/13/73	9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	1	2	3	4	5

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	4-11	3-4
Length of Shroud Time	1:15	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A	83	83	83	83½	84
B	83	83	83	-	83
C	83½	84	84	-	84
D	85	84	85	-	84
Bay	87	87	87	86	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP E

Test Number	1	1	1	1	1
Date	9-13-73	9-13-73	9-13-73	9-13-73	9-13-73
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	178	177	178	177	177
Material Temperature	175	175	175	175	175
Shell Temperature	77	76	77	77	77
Time Poured	5:42	5:55	5:58	6:01	6:05
Duration of Pour	43	42	43	44	44
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP E

Test Number	1	1	1	1	1
Date	9/13/73	9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	3-14	3-13	3-12	3-11	4-14
Length of Shroud Time	1:15	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A	84	83	83	83	84
B	83	82	83	83	
C	83	84	84	84	
D	83	83	83	83	
Bay	87	87	87	86	87

X-Ray Results

Number of Shells Poured	60	60	60	60	06
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP E

Test Number	1				
Date	9-13-73				
Skid Number	21				

Multipour Data (First Pour)

Reservoir Temperature	172				
Cup Temperature	177				
Material Temperature	177				
Shell Temperature	78				
Time Poured	7:32				
Duration of Pour	43				
Multipour Number	2				

Multipour Data (Second Pour)

Reservoir Temperature	-				
Cup Temperature	-				
Material Temperature	-				
Time Poured	-				
Duration of Pour	-				
Multipour Number	-				

Core Melting Data

Time Start	-				
Time Probe Down	-				
Time Finish	-				
Duration of Probe	-				
Probe Temperature	-				
Probe Unit Number	-				

TEST GROUP E

Test Number	1				
Date	9/13/73				
Skid Number	21				

Cooling Bay Data

Cooling Bay - Position	4-6				
Length of Shroud Time	1:15				
Cooling Bay Temp. Averages					
A	82				
B	-				
C	-				
D					
Bay	84				

X-Ray Results

Number of Shells Poured	60				
Number of Criticals	0				
Number of Minors	0				
Number of Cavities	0				
Number of Good Shells	60				

TEST GROUP E

Test Number	2	2	2	2	2
Date	9/13/73	9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	177	175	175	175	175
Cup Temperature	176	178	178	178	177
Material Temperature	175	175	175	175	176
Shell Temperature	76	77	75	77	76
Time Poured	6:09	6:42	6:51	6.54	6:57
Duration of Pour	45	45	45	43	42
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	6:15	6:47	6:56	6:59	7:02
Time Probe Down	-	-	-	-	-
Time Finish	6:17:30	6:49:30	6:58:30	7:01:30	7:04:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	227	227	-	227	-
Probe Unit Number	3	3	4	3	4

TEST GROUP E

Test Number	2	2	2	2	2
Date	9/13/73	9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	4-10	3-11	4-13	3-10	4-12
Length of Shroud Time	1:15	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A	83	84	82	84	82
B	-	83	-	82	-
C	-	84	-	82	-
D	-	83	-	83	-
Bay	87	88	84	86	84

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP E

Test Number	2	2	2	2	2
Date	9/13/73	9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	174	174	174	172	172
Cup Temperature	177	177	177	177	177
Material Temperature	176	178	177	176	175
Shell Temperature	77	75	77	78	77
Time Poured	7:01	7:06	7:23	7:26	7:29
Duration of Pour	44	43	43	42	41
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	7:06	7:11	7:28	7:31	7:34
Time Probe Down	-	-	-	-	-
Time Finish	7:08:30	7:13:30	7:30 30	7:33:30	7:36:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	230	-	-	225	-
Probe Unit Number	3	4	3	4	4

TEST GROUP E

Test Number	2	2	2	2	-
Date	9/13/73	9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	16	17	18	19	20

Cooling Bay Data

Cooling Bay - Position	3-9	4-12	3-5	3-	4-9
Length of Shroud Time	1:15	1 15	1 15	1.15	1 15
Cooling Bay Temp. Averages					
A	84	82	84	84	82
B	82	-	83	82	-
C	82	-	83	82	-
D	83	-	84	83	-
Bay	87	84	87	87	85

X-Ray Results

Number of Shells Poured	60	59*	60	59*	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	59	60	59	60
Maximum Area of Cavity					
Average Area of Cavity					
Median Area of Cavity					
Total Area of Cavity					

*Shell 55 omitted.

TEST GROUP E
TEST NUMBER 3
TEST DATE 9/17/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	179	179	179	176	178
Cup Temperature	176	176	176	179	176
Material Temperature	175	175	175	175	175
Shell Temperature	70	70	70	70	70
Time Poured	5:44	5:48	5:50	5:54	5:58
Duration of Pour	42	42	42	42	41
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	77	77	77	77	77

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP E

Test Number	3	3	3	3	3
Date	9-17-73	9-17-73	9-17-73	9-17-73	9-17-73
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	178
Cup Temperature	176	176	176	176	176
Material Temperature	176	175	176	176	176
Shell Temperature	70	70	71	71	70
Time Poured	6:02	6:05	6:08	6:11	6:15
Duration of Pour	40	42	40	39	39
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP F

Test Number	3	3	3	3	3
Date	9/17/73	9/17/73	9/17/73	9/17/73	9/17/73
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	3-13	3-12	3-11	4-1	
Length of Shroud Time	. 15	1 15	1 15	1 15	1:15
Cooling Bay Temp. Averages					
A	75	75	75	74	74
B	75	75	75	-	-
C	74	74	74	-	-
D	74	75	75	-	-
Bay	76	77	77	76	76

X-Ray Results

Number of Shells Poured	60	60	58*	59**	58***
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	58	59	58

*Shells 3 and 5 omitted.
**Shell 55 omitted.
***Shells 6 and 60 omitted.

TEST GROUP E

Test Number	4	4	4	4	4
Date	9/17/73	9/17/73	9/17/73	9/17/73	9/17/73
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	176	177	177	178	178
Cup Temperature	178	178	178	178	178
Material Temperature	175	175	176	175	176
Shell Temperature	72	68	71	69	70
Time Poured	6:47	6 52	6:55	7:03	7:12
Duration of Pour	55	70 sec	55	40	58
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	6:52	6:57	7:00	7:10	7:17
Time Probe Down	-	-	-	-	-
Time Finish	6:54:30	6:59:30	7:02:30	7:13:00	7:19:30
Duration of Probe	2.5	2.5	2.5	3.0	2.5
Probe Temperature	224	-	-	-	-
Probe Unit Number	3	4	3	4	3

TEST GROUP E

Test Number	4	4	4	4	4
Date	9/17/73	9/17/73	9/17/73	9/17/73	9/17/73
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	3-10	4-3	3-10	4-4	3-9
Length of Shroud Time	1:15	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A	76	73	76	73	76
B	75	-	76	-	76
C	74	-	74	-	74
D	75	-	75	-	76
Bay	76	77	77	77	78

X-Ray Results

Number of Shells Poured	58A	60	59B	59C	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	58	60	59	59	60

A Shells 6 and 27 omitted.
B Shell 17 omitted.
C Shell 5 omitted.

TEST GROUP E

Test Number	4	4	4	4	4
Date	9/17/73	9/17/73	9/17/73	9/17/73	9/17/73
Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	178
Cup Temperature	178	178	178	178	178
Material Temperature	175	175	176	176	177
Shell Temperature	70	71	74	74	71
Time Poured	7:11	7:15	7:20	7:23	7:28
Duration of Pour	53	54	48	43	38
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	7:16	7:20	7:25	7:28	7:33
Time Probe Down	-	-	-	-	-
Time Finish	7:18:30	7:22:30	7:27:30	7:30:30	7:36:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	-	-	-	-	-
Probe Unit Number	4	3	4	3	4

TEST GROUP E

Test Number	4	4	4	4	4
Date	9/17/73	9/17/73	9/17/73	9/17/73	9/17/73
Skid Number	16	17	18	19	20

Cooling Bay Data

Cooling Bay - Position	4-5	-	4-14	3-5	4-6
Length of Shroud Time	1:15	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A	73	76	73	76	74
B	-	76	-	76	-
C	-	74	-	74	-
D	-	76	-	76	-
Bay	77	78	77	78	77

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP E

Test Number	4				
Date	9/17/73				
Skid Number	21				

Multipour Data (First Pour)

Reservoir Temperature	175				
Cup Temperature	178				
Material Temperature	177				
Shell Temperature	70				
Time Poured	7:32				
Duration of Pour	38				
Multipour Number	2				

Multipour Data (Second Pour)

Reservoir Temperature	-				
Cup Temperature	-				
Material Temprature	-				
Time Poured	-				
Duration of Pour	-				
Multipour Number	-				

Core Melting Data

Time Start	7:37				
Time Probe Down	-				
Time Finish	7:39:30				
Duration of Probe	2.5				
Probe Temperature	-				
Probe Unit Number	3				

TEST GROUP E

Test Number	4				
Date	9/17/73				
Skid Number	21				

Cooling Bay Data

Cooling Bay - Position	3-6				
Length of Shroud Time	1:15				
Cooling Bay Temp. Averages					
A	76				
B	76				
C	74				
D	76				
Bay	78				

X-Ray Results

Number of Shells Poured	60				
Number of Criticals	0				
Number of Minors	0				
Number of Cavities	0				
Number of Good Shells	60				

TEST GROUP E

Test Number	5	5	5	5	5
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	177	177	177	177	177
Cup Temperature	178	178	178	178	178
Material Temperature	175	175	175	176	176
Shell Temperature	72	75	73	72	72
Time Poured	5:27	5 30	5:33	5:36	5:39
Duration of Pour	70	47	47	47	44
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP E

Test Number	5	5	5	5	5
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	1	2	3	4	5

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	79	79	79	79	79
B	79	79	79	79	79
C	78	78	78	78	78
D	79	79	79	79	79
Bay	80	80	80	80	80

X-Ray Results

Number of Shells Poured	59*	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	60	60	60	60

*Shell 37 omitted.

TEST GROUP E

Test Number	5	5	5	5	5
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	177	174	174	174	173
Cup Temperature	176	177	177	177	177
Material Temperature	177	178	179	178	178
Shell Temperature	75	75	75	73	75
Time Poured	5:42	6:03	6:06	6:09	6:12
Duration of Pour	45	41	43	45	42
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP E

Test Number	5	5	5	5	5
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	3-6	3-8	3-9	3-10	3-11
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	79	79	79	79	79
B	79	79	79	79	79
C	78	79	79	79	79
D	79	81	81	81	81
Bay	80	81	81	81	81

X-Ray Results

Number of Shells Poured	60	60	60	60	59*
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	59

*Shell 55 omitted, low pour.

[illegible]

Test Number	6	6	6	6	6
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	172	172	174	174	174
Cup Temperature	177	177	178	178	178
Material Temperature	175	175	175	176	175
Shell Temperature	73	73	72	72	74
Time Poured	6:26	6:40	6:44	6:46	6:50
Duration of Pour	58	55	45	45	45
Multipour Number	1.	1	1	:	1

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP E

Test Number	6	6	6	6	6
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	4-11	4-10	3-11	3-12	3-13
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	77	77	78	78	78
B	-	-	79	79	79
C	-	-	77	77	77
D	-	-	79	79	79
Bay	79	79	79	79	79

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

[redacted]

Test Number	6				
Date	9/18/73				
Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	172	173	173	172	172
Cup Temperature	177	178	178	183	178
Material Temperature	175	176	176	176	176
Shell Temperature	72	75	73	73	73
Time Poured	6:54	7:03	7:06	7:12	7:16
Duration of Pour	41	37	39	42	44
Multipour Number	1	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP E

Test Number	6	6	6	6	6
Date	9/18/73	9/18/73	9/18/73	9/18/73	9/18/73
Skid Number	16	17	18	19	20

Cooling Bay Data

Cooling Bay - Position	3-14	4-3	4-4	4-5	4-6
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	78	76	76	76	76
B	79	-	-	-	-
C	77	-	-	-	-
D	79	-	-	-	-
Bay	79	79	79	79	79

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP E

Test Number	6				
Date	9/18/73				
Skid Number	21	22			

Multipour Data (First Pour)

Reservoir Temperature	172	175			
Cup Temperature	178	177			
Material Temperature	177	178			
Shell Temperature	72	75			
Time Poured	7:21	7:34			
Duration of Pour	42	46			
Multipour Number	2	1			

Multipour Data (Second Pour)

Reservoir Temperature	-	-			
Cup Temperature	-	-			
Material Temperature	-	-			
Time Poured	-	-			
Duration of Pour	-	-			
Multipour Number	-	-			

Core Melting Data

Time Start	-	-			
Time Probe Down	-	-			
Time Finish	-	-			
Duration of Probe	-	-			
Probe Temperature	-	-			
Probe Unit Number	-	-			

TEST GROUP E

Test Number	6				
Date	9/18/73				
Skid Number	21	22			

Cooling Bay Data

Cooling Bay - Position		4-7			
Length of Shroud Time	75	75			
Cooling Bay Temp. Averages					
A	77	77			
B	-	-			
C	-	-			
D	-	-			
Bay	79	79			

X-Ray Results

Number of Shells Poured	60	58A			
Number of Criticals	0	0			
Number of Minors	0	0			
Number of Cavities	0	0			
Number of Good Shells	60	60			

A Shells 19 and 25 omitted from test, low pour.

GROUP F - CASTOR WAX

Test #	Explosive Temperature °F*	Shell Temperature °F*
1	176	70
2	176	90
3	184	90
4	184	70

NOTES:

* Nominal temperature - record actual temperature.

1. Use single pour.
2. Pour 4 skids per test.
3. Use wood shroud.
4. Cooling bay temperature was 90°F minimum.
5. Shroud time was 75 minutes, the total cooling time was
6. 3.75 hours minimum.
7. Use additional agitator in reservoir and maintain a minimum lower limit.
8. 100% X-ray all shells.
9. Section and color photograph two (2) shells from each test.

GROUP F DEFECT SUMMARY

Nominal Explosive Temperature in Riser	Nominal Shell Temperature 70°	Nominal Shell Temperature 90°
176°	[1] 0	[2] 14M
184°	[4] 1M	[3] 6C 63M

GROUP F

TEST 1

No defects were found.

TEST 2

There were 14 minor defects found. The last 3 skids of this test had a heavy wax build-up on top of the riser.

TEST 3

There were 6 critical and 63 minor defects found.

TEST 4

There was 1 minor defect found.

TEST 5

No defects were found.

TESTS 6 and 7

No test.

TEST 8

No defects were found.

TEST GROUP F

Test Number	1				
Date	9/19/73				
Skid Number	1	2	3	4	

Multipour Data (First Pour)

Reservoir Temperature	174	174	173	173	
Cup Temperature	176	176	176	176	
Material Temperature	174	177	176	176	
Shell Temperature	70	72	69	74	
Time Poured	5 29	5 35	5 38	5 44	
Duration of Pour	45	45	65	46	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Probe	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP F

Test Number	1				
Date	9/19/73				
Skid Number	1	2	3	4	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75			
Cooling Bay Temp. Averages					
A	92	92	92	93	
B	91	91	91	91	
C	92	91	91	93	
D	90	90	90	90	
Bay	99	99	99	99	

X-Ray Results

Number of Shells Poured	59A	59B	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	59	59	60	60	

A. Shell #58 omitted, low pour.
B. Shell #43 omitted, low pour.

TEST GROUP F

Test Number	2				
Date	9/19/73				
Skid Number	5	6	7	8	

Multipour Data (First Pour)

Reservoir Temperature	174	174	174	175	
Cup Temperature	176	175	175	175	
Material Temperature	176	174	174	175	
Shell Temperature	92-93	93-95	92	92	
Time Poured	5:49	5:55	5:59	6:03	
Duration of Pour	46	55	57	57	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Probe	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP F

Test Number	2				
Date	9/19/73				
Skid Number	5	6	7	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-8	4-11	
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	93	93	93	90	
B	91	92	92	-	
C	92	92	91	-	
D	90	90	90	-	
Bay	99	99	99	94	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	10	0	1	3	
Number of Cavities	14	5	8	5	
Number of Good Shells	50	60	59	57	

TEST GROUP .

Test Number	3				
Date	9/19/73				
Skid Number	9	10	11	1.	

Multipour Data (First Pour)

Reservoir Temperature	188	190	192	196	
Cup Temperature	180	184	186	136	
Material Temperature	182	182	184	184	
Shell Temperature	93	90	92	92	
Time Poured	6 44	6 50	6 56	7·01	
Duration of Pour	43	44	53	40	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Probe	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP F

Test Number	3				
Date	9/19/73				
Skid Number	9	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	91	91	91	91	
B	93	91	91	91	
C	92	92	90	90	
D	89	89	88	89	
Bay	98	98	98	98	

X-Ray Results

Number of Shells Poured	59A	60	59	60	
Number of Criticals	1	0	3	2	
Number of Minors	14	11	21	17	
Number of Cavities	23	14	28	22	
Number of Good Shells	44	49	35	41	

A. Shell #57 omitted, low pour
B. Shell #19 omitted, low pour.

TEST GROUP F

Test Number	4				
Date	9/19/73				
Skid Number	13	14	15	16	

Multipour Data (First Pour)

Reservoir Temperature	196	198	198	198	
Cup Temperature	186	187	18[illegible]	187	
Material Temperature	185	186	186	187	
Shell Temperature	70	70	70	70	
Time Poured	7:10	7:15	7:19	7:24	
Duration of Pour	51	49	39	39	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	-	-	-	-	
Time Probe Down	-	-	-	-	
Time Finish	-	-	-	-	
Duration of Probe	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Unit Number	-	-	-	-	

TEST GROUP F

Test Number	4				
Date	9/19/73				
Skid Number	13	14	15	16	

Cooling Bay Data

Cooling Bay - Position	4-10	3-12	3-13	3-14	
Length of Shroud Time					
Cooling Bay Temp. Averages					
A	90	91	91	-	
B	-	91	91	-	
C	-	88	88	-	
D	-	89	89	-	
Bay	94	98	98	98	

X-Ray Results

Number of Shells Poured	59A	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	1	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	59	60	59	60	

A. Shell #52 omitted, low pour.

TEST GROUP F
TEST NUMBER 5
TEST DATE 10/17/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	178	178	178	178	178
Cup Temperature	177	177	178	178	179
Material Temperature	175	175	176	176	176
Shell Temperature	70	70	70	70	70
Time Poured	9:04	9:08	9·12	9·21	9·26
Duration of Pour	50	54	49	68	78
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	81	81	82	83	83

X-Ray Results

Number of Shells Poured	60	60	60	60	59A
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 1 omitted from test, low pour.

TEST GROUP F
TEST NUMBER 8
TEST DATE 10/17/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	182	182	182	182	183
Cup Temperature	180	178	178	178	178
Material Temperature	177	180	180	180	180
Shell Temperature	70	70	70	70	70
Time Poured	9:32	9:40	9:43	9:45	9:49
Duration of Pour	75	43	40	39	38
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	83	83	82	82	82

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

GROUP G - SORTED HIGH VISCOSITY PETROLITE

Test #	Per Cent Scrap	Number of Skids
1	None	20
2	70%	10

TEST INSTRUCTIONS

1. Use shell temperature of 79^{o}F max.
2. Reservoir agitation (w/additional agitator) and minimum lower level limit.
3. Use single pour, 178^{o}F max.
4. Use picatinny shroud.
5. Cooling bay temperature ambient and record.
6. Shroud time, 1 1/4 hrs minimum.
7. Total cooling time, 3 3/4 hrs minimum.
8. 100% X-ray all shells.
9. Section and color photograph two (2) shells from each test.

GROUP G - DEFECT SUMMARY

Test No.	Per Cent Scrap	Defects
1	0	0
2	70	0

TEST GROUP G

Test Number	1	1	1	1	1
Date	9/20/73				
Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	175	175	177	175	174
Shell Temperature	75	75	73	75	75
Time Poured	5:38	5:42	5:45	5:50	5:53
Duration of Pour	53	55	57	57	58
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP G

Test Number	1				
Date	9/20/73				
Skid Number	1	2	3	4	5

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	4-11	3-3	3-4
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	82	82	83	83	83
B	81	85	-	85	84
C	84	84	-	84	84
D	84	84	-	84	84
Day	87	87	87	87	86

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP G

Test Number	1				
Date	9/20/73				
Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	176	176	179	178	178
Cup Temperature	176	176	177	177	177
Material Temperature	175	175	176	176	175
Shell Temperature	73	72	70	75	73
Time Poured	6:00	6:08	6:12	6:15	6:34
Duration of Pour	59	61	58	58	57
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP G

Test Number	1				
Date	9/20/73				
Skid Number	6	7	8	9	10

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	83	83	84	84	83
B	84	84	84	84	84
C	84	84	84	84	84
D	84	84	84	84	84
Bay	86	86	86	86	86

X-Ray Results

Number of Shells Poured	59A	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	60	60	60	60

A Shell 21 omitted from test (X-rayed, OK).

TEST GROUP G

Test Number	1				
Date	9/20/73				
Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	178
Cup Temperature	177	177	177	177	177
Material Temperature	175	175	176	176	176
Shell Temperature	72	70	73	74	73
Time Poured	6:40	6:44	6:47	6:50	6:53
Duration of Pour	-	55	57	53	54
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST GROUP G

Test Number	1				
Date	9/20/73				
Skid Number	11	12	13	14	15

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	83	83	83	83	83
B	84	84	84	84	-
C	83	83	83	83	-
D	84	84	84	84	-
Bay	86	86	86	86	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP G

Test Number	1				
Date	9/20/7				
Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	178
Cup Temperature	177	177	176	176	177
Material Temperature	175	175	177	176	176
Shell Temperature	75	77	78	75	75
Time Poured	6 57	7..5	7 29	7 31	7 35
Duration of Pour	55	54	54	55	55
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

Reservoir Temperature	-	-	-	-	-
Cup Temperature	-	-	-	-	-
Material Temperature	-	-	-	-	-
Time Poured	-	-	-	-	-
Duration of Pour	-	-	-	-	-
Multipour Number	-	-	-	-	-

Core Melting Data

Time Start	-	-	-	-	-
Time Probe Down	-	-	-	-	-
Time Finish	-	-	-	-	-
Duration of Probe	-	-	-	-	-
Probe Temperature	-	-	-	-	-
Probe Unit Number	-	-	-	-	-

TEST [illegible]

Test Number	1				
Date	9/20/73				
Skid Number	16	17	18	19	20

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-12	4-13	4-14
Length of Shroud Time	75	75	75	75	75
Cooling Bay Temp. Averages					
A	83	-	83	83	83
B	-	-	-	-	-
C	-	-	-	-	-
D	-	-	-	-	-
Bay	85	85	85	85	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60

TEST GROUP G
TEST NUMBER 2
TEST DATE 9/21/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	177	176	177	177	177
Cup Temperature	176	176	176	176	176
Material Temperature	176	177	176	176	176
Shell Temperature	73	77	75	78	73
Time Poured	2:22	2:26	2:35	2:28	2:41
Duration of Pour	50	53	54	52	53
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	5-1	5-2	5-3	5-4	5-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	87	87	86

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP G
TEST NUMBER 2
TEST DATE 9/21/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	178	177	176	176	176
Cup Temperature	175	175	175	175	175
Material Temperature	176	176	176	177	177
Shell Temperature	80	76	74	77	76
Time Poured	3:18	3:24	3:28	3:32	3:36
Duration of Pour	51	53	52	54	[illegible]
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	5-6	5-7	5-8	5-9	5-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	88	86	88	88	88

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

GROUP H - BAD LOT PETROLITE

Test No.	Percent Scrap	Defects
1	0	0
2	40	0

NOTES:

1. Shell temperature 75° to 79°F.
2. Material temperature 174 to 178°F.
3. Single pour.
4. 20 skids per test.
5. Use Picatinny shroud.
6. Record cooling bay temperature.
7. Shroud time 1.25 hours.
8. Total cooling time 3.75 hours.
9. 100% X-ray all shells.
10. Reservoir agitation (with additional agitator) and maintain a minimum lower limit.
11. Use unsorted "Bad Lot" Petrolite Lot HOL 053-5095 or HOL 053-5096.

TEST GROUP H
TEST NUMBER 1
TEST DATE 9/24/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	175	174	176	177	180
Cup Temperature	178	177	177	180	180
Material Temperature	174	174	173	175	174
Shell Temperature	78	77	76	76	77
Time Poured	6:58	7:04	7.10	7:15	7:18
Duration of Pour	48	57	58	58	57
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Tire	75	75	75	75	75
Average Cooling Bay Temp.	83	83	83	83	83

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP H
TEST NUMBER 1
TEST DATE 9/24/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	180	180	180	180	181
Cup Temperature	180	180	180	180	180
Material Temperature	174	174	174	177	178
Shell Temperature	75	78	75	77	77
Time Poured	7:23	7:28	7:34	7:38	7:42
Duration of Pour	54	49	50	52	52
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	83	83	83	83	83

X-Ray Results

Number of Shells Poured	59A	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	60	50	60	60
Number of Shells with Porosity & crystallization	1	0	0	0	0

A Shell 55 omitted, low pour (X-rayed - no defect).

TEST GROUP H
TEST NUMBER 1
TEST DATE 9/24/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	181	182	182	181	180
Cup Temperature	180	180	180	180	178
Material Temperature	176	176	176	176	176
Shell Temperature	76	76	75	77	77
Time Poured	7:47	7:51	7:54	7:56	7:59
Duration of Pour	54	51	-	50	52
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	85	85	85	85	85

X-Ray Results

Number of Shells Poured	60	60	60	60	59A
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 55 omitted, low pour (X-rayed - critical defect).

TEST GROUP H
TEST NUMBER 1
TEST DATE 9/24/73

Skid Number	16	17	18	19	20

Multipour Data

Reservoir Temperature	180	181	180	180	180
Cup Temperature	179	180	180	180	179
Material Temperature	176	178	176	177	177
Shell Temperature	77	77	77	77	77
Time Poured	8:03	8:05	8:16	8:18	8:20
Duration of Pour	48	49	45	45	-
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-4	4-5	4-6
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	85	85	85	85	85

X-Ray Results

Number of Shells Poured	60	60	59A	59B	60
Number of Criticals	0	0	1	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	1	0	0
Number of Good Shells	60	60	58	59	60
Number of Shells with Porosity & crystallization	0	0	0	0	-

A Shell 11 omitted, low pour (X-rayed, critical defect).
B Shell 55 omitted, low pour (X-rayed, critical defect).

TEST GROUP H
TEST NUMBER 2
TEST DATE 9/25/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	175	174	174	174	174
Cup Temperature	178	177	176	177	176
Material Temperature	176	176	176	175	176
Shell Temperature	77	77	77	77	78
Time Poured	5:38	5:41	5:45	5:48	5:56
Duration of Pour	50	50	54	49	50
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	90	90	90	90	91

X-Ray Results

Number of Shells Poured	60	60	59A	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	59	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 36 omitted, low pour.

TEST GROUP H
TEST NUMBER 2
TEST DATE 9/25/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	174	174	174	174	176
Cup Temperature	177	177	177	176	176
Material Temperature	176	176	177	176	175
Shell Temperature	78	79	74	75	76
Time Poured	6:06	6:07	6:12	6:17	6:41
Duration of Pour	51	49	49	51	56
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	91	91	91	91	92

X-Ray Results

Number of Shells Poured	60	59A	60	59B	59C
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	[illegible]	0	0
Number of Good Shells	60	59	60	59	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 42 omitted from test.
B Shell 42 omitted from test.
C Shell 15 omitted from test, low pour.

TEST GROUP H
TEST NUMBER 2
TEST DATE 9/25/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	176	176	174	174	174
Cup Temperature	176	176	176	175	176
Material Temperature	175	175	175	176	175
Shell Temperature	77	78	76	75	76
Time Poured	6:48	6:57	7:04	7:07	7:14
Duration of Pour	55	54	57	58	59
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	41
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	[illegible]	92	92	92	88

X-Ray Results

Number of Shells Poured	59A	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	[illegible]	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	60	[illegible]	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 57 omitted, low pour.

TEST GROUP H
TEST NUMBER 2
TEST DATE 9/25/73

Skid Number	16	17	18	19	20

Multipour Data

Reservoir Temperature	174	174	176	176	176
Cup Temperature	176	176	177	176	176
Material Temperature	176	176	177	180	179
Shell Temperature	74	75	76	-	73
Time Poured	7:29	[illegible]	7:42	7:45	7:50
Duration of Pour	52	56	47	51	48
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-4	4-5	4-6
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	88	88	88	88	88

X-Ray Results

Number of Shells Poured	60	60	60	60	57A
Number of Criticals	0	0	0	0	[illegible]
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	57
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shells 58, 59, and 60 omitted, shells "hot."

TEST GROUP H
TEST NUMBER 3
TEST DATE 10/16/73

Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	177	78	177	177	176
Cup Temperature	177	177	177	176	176
Material Temperature	178	177	177	176	176
Shell Temperature	73	74	75	73	74
Time Poured	5 40	5 44	5 48	5 53	5 56
Duration of Pour	71	55	57	52	50
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	.	75	75
Average Cooling Bay Temp.	83	83	83	84	83

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP H
TEST NUMBER 3
TEST DATE 10/16/73

Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	178	176
Material Temperature	176	176	176	176	176
Shell Temperature	72	72	72	72	74
Time Poured	5 59	6 05	6 10	6·14	6·39
Duration of Pour	47	54	55	53	52
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	83	83	84	84	82

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP H
TEST NUMBER 3
TEST DATE 10/16/73

Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	174	176	176	176	176
Cup Temperature	174	177	176	176	176
Material Temperature	175	175	176	176	176
Shell Temperature	73	72	73	74	72
Time Poured	6:42	6:45	6:47	6:55	5:58
Duration of Pour	53	53	52	51	51
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	82	82	82	82	81

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP H
TEST NUMBER 3
TEST DATE 10/16/73

Skid Number	16	17	18	19	

Multipour Data (First Pour)

Reservoir Temperature	[illegible]	176	176	176	
Cup Temperature	176	176	176	176	
Material Temperature	176	176	176	176	
Shell Temperature	73	73	74	74	
Time Poured	7:02	7:22	7:26	7:31	
Duration of Pour	51	48	49	50	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	2-11	2-12	2-13	2-14	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	81	81	81	81	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Critical	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

GROUP I

TEST 1

There were 2 minor defects found.

TEST 2

No defects were found.

Wax was observed on top of the riser for the first 5 skids in this test.

TEST 3

There were 2 minor defects found. Skids 1 and 2 had an unusually high number of low pours due to problems with the multipour. The water temperature around the cups was increased before pouring skid 3 to alleviate the problems with the multipour. Wax was observed on top of 8 of the 21 skids poured.

TEST 4

There were 3 critical and 14 minor defects found. Wax was observed on top of 4 of the 10 skids in the test.

TEST 5

There were 2 critical and 10 minor defects found. It should be pointed out that the 2 skids with a steel temperature of 74°F. did not have any defects while the other 5 skids (with a steel temperature of 75°F.) did. This relationship does not hold true for Test 4.

TEST GROUP I
TEST NUMBER 1
TEST DATE 9/26/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	176	176	176	175	175
Cup Temperature	176	176	176	176	176
Material Temperature	176	176	176	176	175
Shell Temperature	78	80	79	78	78
Time Poured	5·31	5 36	5 41	5 49	5 53
Duration of Pour	53	53	54	59	60
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	80	76	75	75	77
Average Cooling Bay Temp.	92	92	92	92	93

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	1	0	0
Number of Cavities	1	0	1	0	0
Number of Good Shells	60	60	59	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP I
TEST NUMBER 1
TEST DATE 9/26/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	174	174	174	174	174
Cup Temperature	176	176	175	176	175
Material Temperature	177	176	176	176	176
Shell Temperature	79	81	80	78	78
Time Poured	5:57	6 03	6 06	6 11	6 14
Duration of Pour	61	54	53	53	53
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	93	93	93	93	93

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	0	0	0	0
Number of Minors	0	0	1	0	0
Number of Cavities	1	0	1	1	0
Number of Good Shells	59	60	59	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP I
TEST NUMBER 2
TEST DATE 9/26/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	174	174	174	175	176
Cup Temperature	175	175	176	176	176
Material Temperature	174	174	176	176	176
Shell Temperature	77	79	78	77	79
Time Poured	6:55	7 00	7 06	7 11	7 15
Duration of Pour	59	59	72	53	43
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	70	75	75	75	75
Average Cooling Bay Temp.	91	93	93	93	90

X-Ray Results

Number of Shells Poured	60	60	58A	57B	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	58	57	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shells 10 and 35 omitted, low pours.
B Shells 5, 34, and 35 omitted, low pours.

TEST GROUP I
TEST NUMBER 2
TEST DATE 9/26/73

Skid Number	16	17	18	19	20

Multipour Data

Reservoir Temperature	176	178	178	174	175
Cup Temperature	176	176	175	174	175
Material Temperature	176	178	178	176	176
Shell Temperature	79	79	79	79	79
Time Poured	7 19	7 22	7 26	7 30	7 33
Duration of Pour	44	46	38	39	37
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-4	4-5	4-6
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	90	90	90	90	90

X-Ray Results

Number of Shells Poured	59A	58B	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	58	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 5 omitted, low pour.
B Shells 40 and 41 omitted.

TEST GROUP I
TEST NUMBER 3
TEST DATE 9/27/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	172	172	174	176	172
Cup Temperature	175	185	185	190	189
Material Temperature	175	175	175	175	176
Shell Temperature	75	76	76	76	73
Time Poured	5 54	6 02	6 [illegible]	6 11	6 14
Duration of Pour	75	90	55	55	56
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	3-13
Length of Shroud Time	76	75	75	75	75
Average Cooling Bay Temp.	93	92	92	92	92

X-Ray Results

Number of Shells Poured	49A	55B	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	1	0	0
Number of Cavities	0	0	1	1	0
Number of Good Shells	49	55	59	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shells 1, 4, 5, 7, 8, 10, 13, 15, 56, 59, 60 omitted, low pour.
B Shells 1, 5, 13, 58, 59 omitted, low pour.

TEST GROUP [illegible]
TEST NUMBER 3
TEST DATE 9/27/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	174	173	174	174	173
Cup Temperature	186	184	184	176	179
Material Temperature	175	178	178	180	179
Shell Temperature	78	76	75	75	75
Time Poured	6 17	6.21	6 25	6.28	6.31
Duration of Pour	60	44	45	45	43
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-14	4-1	4-2	4-3	4-4
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	92	91	91	91	91

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	1	0
Number of Cavities	0	0	1	1	0
Number of Good Shells	60	60	60	59	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP I
TEST NUMBER 3
TEST DATE 9/27/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	171	172	173	174	173
Cup Temperature	178	182	186	186	186
Material Temperature	175	176	176	176	179
Shell Temperature	-	77	75	75	75
Time Poured	7 12	7 16	7 20	7 25	7 29
Duration of Pour	54	55	49	46	45
Multipour Number	[illegible]	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-5	4-6	4-7	4-9	4-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	91	91	91	91	91

X-Ray Results

Number of Shells Poured	60	60	60	60	58A
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	58
Number of Shells with Porosity & crystallization	0	0	1	0	0

A Shells 44 and 56 omitted.

TEST GROUP I
TEST NUMBER 3
TEST DATE 9/27/73

Skid Number	16	17	18	19	20

Multipour Data

Reservoir Temperature	174	174	174	172	171
Cup Temperature	186	178	178	176	176
Material Temperature	179	179	179	178	180
Shell Temperature	72	74	74	74	74
Time Poured	7 32	7 36	7 40	7 46	7 51
Duration of Pour	45	41	42	40	38
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-11	4-12	4-13	4-13	4-14
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	91	91	91	91	91

X-Ray Results

Number of Shells Poured	60	60	60	55A	52B
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	55	52
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shells 2, 3, 56, 57, and 58 omitted.
B Shells 1, 2, 3, 38, 49, 55, 56, and 57 omitted.

TEST GROUP 1
TEST NUMBER 3
TEST DATE 9 [illegible] 3

Skid Number	21				

Multipour Data

Reservoir Temperature	171				
Cup Temperature	[illegible]				
Material Temperature	182				
Shell Temperature	77				
Time Poured	7 56				
Duration of Pour	35				
Multipour Number	2				

Cooling Bay Data

Cooling Bay - Position	3-8				
Length of Shroud Time	75				
Average Cooling Bay. Temp.	92				

X-Ray Results

Number of Shells Poured	60				
Number of Criticals	0				
Number of Minors	0				
Number of Cavities	0				
Number of Good Shells	60				
Number of Shells with Porosity & crystallization	0				

TEST GROUP 1
TEST NUMBER [illegible]
TEST DATE 9/.8/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	175	175	175	175	173
Cup Temperature	180	180	180	176	177
Material Temperature	176	175	176	176	177
Shell Temperature	74	74	75	75	75
Time Poured	1 58	[illegible] 02	2 05	2 07	2 27
Duration of Pour	-	53	55	54	54
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	7-1	7-2	7-3	7-4	7-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	86	86	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	2	0	0	1	0
Number of Minors	2	0	2	2	4
Number of Cavities	4	0	2	3	5
Number of Good Shells	56	60	58	57	58
Number of Shells with Porosity & crystallization	0	0	0	0	1

TEST GROUP I
TEST NUMBER 4
TEST DATE 9/28/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	173	174	175	175	175
Cup Temperature	177	175	175	175	175
Material Temperature	176	176	175	175	175
Shell Temperature	75	75	75	75	75
Time Poured	2:30	2:34	2:37	2:39	2:43
Duration of Pour	55	-	56	56	54
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	7-6	7-7	7-8	7-9	7-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	87				87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	2	1	1	0	0
Number of Cavities	3	1	3	0	0
Number of Good Shells	58	59	59	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP I
TEST NUMBER 5
TEST DATE 9/28/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	185	184	184	184	185
Cup Temperature	175	175	175	175	175
Material Temperature	177	176	176	177	177
Shell Temperature	75	74	75	75	75
Time Poured	2:53	2:56	3:00	3:06	3:11
Duration of Pour	51	57	52	47	43
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	7-11	7-12	7-13	7-14	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	88	88	88	88	94

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	2	0
Number of Minors	2	0	4	1	2
Number of Cavities	2	0	4	4	2
Number of Good Shells	58	60	56	57	58
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP I
TEST NUMBER 5
TEST DATE 9/28/73

Skid Number	16	17			

Multipour Data

Reservoir Temperature	185	185			
Cup Temperature	175	175			
Material Temperature	177	176			
Shell Temperature	75	74			
Time Poured	3:14	3:18			
Duration of Pour	46	52			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	3-11	3-12			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	94	94			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	0	0			
Number of Minors	1	0			
Number of Cavities	1	0			
Number of Good Shells	59	60			
Number of Shells with Porosity & crystallization	0	0			

GROUP J INDRAMIC

Test No.	Number of Skids	Percent Scrap	Shell Temperature	Material Temperature	Probe Depth	Probe Time
1	4	0	70	176	-	-
2	4	0	90	176	-	-
3	4	0	90	184	-	-
4	4	0	70	184	-	-
5	4	40	80-85	180-184	3.5	2.5
6	4	40	80-85	180-184	3.5	15 seconds
7	4	40	80-85	180-184	1.5	2.5
8	4	40	80-85	180-184	1.5	15 seconds
9	4	40	80-85	180-184	-	-
10	10	40	75-79	173-179	-	-
11	4	40	90	173-179	3.5	2.5
12	4	40	90	173-179	3.5	5
13	2	40	90	173-179	-	-
14	10	0	75-79	173-179	-	-
15	10	70	75-79	173-179	-	-
16	15	40	75-79	173-179	-	-
17	5	40	75-79	180	-	-
18	5	40	80-85	180	-	-
19	5	40	75-79	184	-	-
20	5	40	80-85	184	-	-

NOTES:

1. Use additional agitator in reservoir and maintain a minimum lower limit.
2. Single pour all skids.
3. Picatinny shroud was used.
4. Shroud time was 75 minutes.
5. The total cooling time was 3.75 hours.
6. Temperatures are nominal, the actual temperature was recorded.
7. All shells were 100% X-rayed.
8. Cooling bay temperature was ambient and recorded except for Tests 1 thru 4, for which a minimum temperature of 90°F was maintained.
9. Probe depths are measured from the breakoff point in the riser.

GROUP J

TEST 1

No defects were found.

TEST 2

There were 39 critical and 15 minor defects found. Wax was observed on top of the risers on skids 5 and 8.

TEST 3

There were 126 critical and 86 minor defects found. All of the risers were covered with wax. The wax covered 20 to 60% of the surface of the explosive in the riser. Prior to pouring the skids in this test, a layer of liquid material was observed floating on top of the explosive in Kettle 1. A sample of this material was removed and it was determined that the material was predominantly wax.

TEST 4

There were 6 critical defects found. Approximately 50 to 70% of the explosive surface in ths risers were covered with wax. All of the defects occurred on the last two skids poured for the day.

TEST 5

There was 1 critical and 2 minor defects found.

TEST 6

There were 3 critical and 4 minor defects found.

TEST 7

There were 19 critical and 17 minor defects found. Wax covering 15 to 20% of the explosive surface in ths risers was observed on all of the skids.

TEST 8

There were 12 critical and 34 minor defects found. The last three skids in the days test were poured using virgin material. This was necessary due to the lack of scrap. Wax covering 50 to 60% of the explosive surface was noted on the last three skids. It should be noted that the first skid in the test, poured with 40% scrap, had the lowest percentage of defects of any skid in this test.

TEST 9

There were 7 minor defects found. Skid 1 was to be probed but it would not fit under the probe machine. The shroud was removed when the attempt was made to place the skid under the probe machine. This skid had 5 minor defects.

TEST 10

No defects were found.

TEST 11

There were 3 critical and 30 minor defects found.

TEST 12

There were [illegible] critical and 18 minor defects found. Mechanical problems were encountered in the multipour unit resulting in low pours in row 6 through 60 on several skids poured prior to skid 18.

TEST 7

There were 19 critical and 17 minor defects found. Wax covering 15 to 20% of the explosive surface in ths risers was observed on all of the skids.

TEST 8

There were 12 critical and 34 minor defects found. The last three skids in the days test were poured using virgin material. This was necessary due to the lack of scrap. Wax covering 50 to 60% of the explosive surface was noted on the last three skids. It should be noted that the first skid in the test, poured with 40% scrap, had the lowest percentage of defects of any skid in this test.

TEST 9

There were 7 minor defects found. Skid 1 was to be probed but it would not fit under the probe machine. The shroud was removed when the attempt was made to place the skid under the probe machine. This skid had 5 minor defects.

TEST 10

No defects were found.

TEST 11

There were 3 critical and 30 minor defects found.

TEST 12

There were [illegible] critical and 18 minor defects found. Mechanical problems were encountered in the multipour unit resulting in low pours in row 6 through 60 on several skids poured prior to skid 18.

TEST 13

There were 5 critical and 26 minor defects found on the 2 skids in this test.

TEST 14

No defects were found.

TEST 15

No defects were found. Skids 19 and 20 (last two skids in the test) contained less than 70% scrap due to a lack of scrap material.

TEST 16

No defects were found.

TEST 17

No defects were found.

TEST 18

One minor defect was found.

TEST 19

There were 2 critical and 2 minor defects found. All of the defects occurred on skid 15 which had the highest steel temperature (78°F.). This skid was placed in cooling bay 3 rather than cooling bay 4 as were the rest of the skids in this test. It should be pointed out that the temperatures were in the load to middle 80's in both cooling bays.

TEST 20

There were 11 critical and 16 minor defects found.

TEST 21

No defects were found.

TEST GROUP J
TEST NUMBER 1
TEST DATE 10/1/73

Skid Number	1	2	3	4	

Multipour Data

Reservoir Temperature	175	176	177	178	
Cup Temperature	175	175	179	177	
Material Temperature	175	176	176	175	
Shell Temperature	72	71	71	72	
Time Poured	5.30	5·40	5·45	5 49	
Duration of Pour	150	53	50	52	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	100	90	85	81	
Average Cooling Bay Temp.	93	93	93	92	

X-Ray Results

Number of Shells Poured	52A	60	60	50	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	52	60	60	60	
Number of Shells with Porosity & crystallization	1	0	0	60	

A Shells 1, 2, 3, 5, 6, 56, 57, and 58 omitted, low pour.

TEST GROUP J
TEST NUMBER 2
TEST DATE 10/1/73

Skid Number	5	6	7	8	

Multipour Data

Reservoir Temperature	176	176	176	176	
Cup Temperature	179	179	180	178	
Material Temperature	175	176	176	176	
Shell Temperature	92	92	93	93	
Time Poured	6:12	6 17	6 22	6·26	
Duration of Pour	66	50	49	61	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	93	93	93	93	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	2	12	12	13	
Number of Minors	0	4	3	8	
Number of Cavities	3	16	15	21	
Number of Good Shells	58	44	45	39	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP J
TEST NUMBER 3
TEST DATE 10/1/73

Skid Number	9	10	11	12	

Multipour Data

Reservoir Temperature	196	196	187	186	
Cup Temperature	194	195	184	182	
Material Temperature	188	187	189	188	
Shell Temperature	90	90	93	94	
Time Poured	7:15	7:19	7.36	7:40	
Duration of Pour	46	53	37	39	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	81	77	75	75	
Average Cooling Bay Temp.	93	93	93	93	

X-Ray Results

Number of Shells Poured	60	60	59A	60	
Number of Criticals	10	18	52	46	
Number of Minors	37	34	5	10	
Number of Cavities	47	52	58	58	
Number of Good Shells	13	8	2	4	
Number of Shells with Porosity & crystallization	0	0	0	0	

A Shell 3 omitted from test, low pour.

TEST GROUP J
TEST NUMBER 4
TEST DATE 10/1/7

Skid Number	13	14	15	16	

Multipour Data

Reservoir Temperature	186	186	186	186	
Cup Temperature	182	182	183	184	
Material Temperature	186	186	185	183	
Shell Temperature	72	71	70	70	
Time Poured	7 44	7 47	7:5[illegible]	7 54	
Duration of Pour	40	40	40	41	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-13	3-14	4-1	4-2	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	93	93	85	85	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP
TEST NUMBER ..
TEST DATE [illegible] 1/7[illegible]

Skid Number		18			

Multipour Data

Reservoir Temperature	186	186			
Cup Temperature	183	182			
Material Temperature	184	185			
Shell Temperature	72	73			
Time Poured	7:58	8:01			
Duration of Pour	40	38			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	4-3	4-4			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	85	85			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	4	2			
Number of Minors	0	0			
Number of Cavities	4	2			
Number of Good Shells	56	58			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP J
TEST NUMBER 5
TEST DATE 10/2/73

Skid Number	2	3	6	7	

Multipour Data (First Pour)

Reservoir Temperature	186	184	182	183	
Cup Temperature	179	178	179	178	
Material Temperature	184	184	180	184	
Shell Temperature	82	83	82	81	
Time Poured	5:20	5:25	5:52	5:56	
Duration of Pour	37	36	38	38	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	5:25	5:30	5:57	6:01	
Time Probe Down	-	-	-	-	
Time Finish	5:27:30	5:32:30	5:59:30	6:03:30	
Duration of Probe	2.5	2.5	2.5	2.5	
Probe Temperature	-	-	-	-	
Probe Steam Pressure	5	5	5	5	
Probe Unit Number	4	4	4	4	

TEST GROUP I
TEST NUMBER 5
TEST DATE 10/2/73

Skid Number	2	3	6	7	

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-6	4-7	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	90	90	90	90	

X-Ray Results

Number of Shells Poured	59A	60	60	60	
Number of Criticals	0	1	0	0	
Number of Minors	2	0	0	0	
Number of Cavities	2	1	0	0	
Number of Good Shells	57	59	60	60	
Number of Shells with Porosity & Crystallization	0	0	0	0	

A Shell 9 omitted from test, low pour.

TEST GROUP J
TEST NUMBER 6
TEST DATE 10/2/73

Skid Number	8	9	10	11	

Multipour Data (First Pour)

Reservoir Temperature	184	184	184	184	
Cup Temperature	178	176	178	176	
Material Temperature	182	182	182	182	
Shell Temperature	82	81	83	83	
Time Poured	6:01	6 08	6·11	6 15	
Duration of Pour	38	38	39	39	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	6·06	6.13	6 16	6·20	
Time Probe Down	-	-	-		
Time Finish	6:06·15	6·13:15	6:16:15	6 20 15	
Duration of Probe	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Steam Pressure	5	5	5	5	
Probe Unit Number	4	4	4	4	

TEST GROUP J
TEST NUMBER 6
TEST DATE 10/2/73

Skid Number	8	9	10	11	

Cooling Bay Data

Cooling Bay - Position	4-14	4-13	4-12	4-11	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	90	90	90	90	

X-Ray Results

Number of Shells Poured	59A	59B	60	60	
Number of Criticals	1	0	0	3	
Number of Minors	0	0	1	3	
Number of Cavities	1	0	2	6	
Number of Good Shells	58	59	59	54	
Number of Shells with Porosity & Crystallization	0	0	0	0	

A Shell 55 omitted from test, low pour.
B Shell 55 omitted from test, low pour.

TEST GROUP J
TEST NUMBER 7
TEST DATE 10/2/73

Skid Number	15	16	17	18	

Multipour Data (First Pour)

Reservoir Temperature	182	182	182	182	
Cup Temperature	178	178	182	178	
Material Temperature	184	183	183	183	
Shell Temperature	83	82	82	83	
Time Poured	6:52	6:55	6:58	7:06	
Duration of Pour	44	38	38	38	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	6:57	7:00	7:04	7:11	
Time Probe Down	-	-	-	-	
Time Finish	6:59:30	7:02:30	7:06:30	7:13:30	
Duration of Probe	2.5	2.5	2.5	2.5	
Probe Temperature	-	-	-	-	
Probe Steam Pressure	5	5	5	5	
Probe Unit Number	4	4	4	-	

TEST GROUP J
TEST NUMBER 7
TEST DATE 10/2/73

Skid Number	15	16	17	18	

Cooling Bay Data

Cooling Bay - Position	3-4	3-5	3-6	3-7	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	95	94	94	94	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	3	1	4	11	
Number of Minors	9	3	2	3	
Number of Cavities	12	4	7	15	
Number of Good Shells	48	56	54	46	
Number of Shells with Porosity & Crystallization	0	0	0	0	

TEST GROUP J
TEST NUMBER 8
TEST DATE 10/2/73

Skid Number	19	20	21	22	

Multipour Data (First Pour)

Reservoir Temperature	[illegible]	183	184	184	
Cup Temperature	178	177	178	178	
Material Temperature	184	184	184	184	
Shell Temperature	83	-	84	83	
Time Poured.	7 11	7 36	7 40	7 42	
Duration of Pour	38	43	39	40	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7 16	7 41	7 45	7 47	
Time Probe Down	-	-	-	-	
Time Finish	7.16 15	7.41 15	7 45 15	7 47 15	
Duration of Probe	-	-	-	-	
Probe Temperature	-	-	-	-	
Probe Steam Pressure	5	5	5	5	
Probe Unit Number	4	4	4	-	

TEST GROUP J
TEST NUMBER 8
TEST DATE 10/2/73

Skid Number	19	20	21	22	

Cooling Bay Data

Cooling Bay - Position	3-8	3-9	3-10	3-11	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	94	94	93	94	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	3	0	5	4	
Number of Minors	2	16	9	7	
Number of Cavities	5	17	14	11	
Number of Good Shells	55	44	46	49	
Number of Shells with Porosity & Crystallization	0	0	0	0	

TEST GROUP J
TEST NUMBER 9
TEST DATE 10/2/73

Skid Number	1	12	13	14	

Multipour Data (First Pour)

Reservoir Temperature	189	182	182	182	
Cup Temperature	178	178	178	178	
Material Temperature	183	182	182	181	
Shell Temperature	82	82	83	83	
Time Poured	5:16	6:41	6:45	6:49	
Duration of Pour	-	40	41	41	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	4-1	3-1	3-2	3-3	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	90	95	95	95	

X-Ray Results

Number of Shells Poured	59A	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	5	0	2	0	
Number of Cavities	5	0	2	0	
Number of Good Shells	54	60	58	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

A Shell 9 omitted, low pour.

TEST GROUP J
TEST NUMBER 10
TEST DATE 10/3/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	176	176	176	176	176
Cup Temperature	174	174	174	174	174
Material Temperature	176	176	176	176	175
Shell Temperature	79	79	79	78	78
Time Poured	5:26	5:31	5:37	5:43	5:46
Duration of Pour	55	41	41	45	43
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	94	94	94	94	94

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 10
TEST DATE 10 3 73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	176	176	176	176	175
Cup Temperature	174	174	174	174	174
Material Temperature	175	176	175	176	175
Shell Temperature	79	77	77	79	79
Time Poured	5 50	5 55	6 03	6 07	6 1[illegible]
Duration of Pour	42	42	50	45	44
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	94	94	94	94	94

X-Ray Results

Number of Shells Poured	60	55A	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	55	60	60	60
Number of Shell with Porosity & crystallization	0	0	0	0	0

A Shells 6, 30, 36, 42, 60 omitted, low pour.

TEST GROUP J
TEST NUMBER 11
TEST DATE 10/3/73

Skid Number	12	13	14	15	

Multipour Data (First Pour)

Reservoir Temperature	176	176	175	176	
Cup Temperature	173	172	179	178	
Material Temperature	175	174	175	175	
Shell Temperature	95	95	93	90	
Time Poured	6:54	7 00	7:07	7 14	
Duration of Pour	65	49	51	50	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7:00	7 05	7 12	7 19	
Time Probe Down	-	-	-	-	
Time Finish	7 02:30	7,07 30	7 14 30	7 21·30	
Duration of Probe	2.5	2.5	2.5	2.5	
Probe Temperature	218	-	-	-	
Probe Steam Pressure	5	5	5	5	
Probe Unit Number	4	4	4	4	

TEST GROUP J
TEST NUMBER 11
TEST DATE 10/3/73

Skid Number	12	13	14		

Cooling Bay Data

Cooling Bay - Position	4-1	4-2	4-3	4-4	
Length of Shroud Time	75	7'	75	75	
Average Cooling Bay Temp.	90	69	90	90	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	2	1	0	
Number of Minors	10	8	6	5	
Number of Cavities	13	10	2	6	
Number of Good Shells	50	50	53	54	
Number of Shells with Porosity & Crystallization	0	0	0	0	

TEST GROUP J
TEST NUMBER 12
TEST DATE 10/3/73

Skid Number	16	17	18	20	

Multipour Data (First Pour)

Reservoir Temperature	179	188	180	179	
Cup Temperature	180	180	178	178	
Material Temperature	176	176	178	177	
Shell Temperature	90	91	92	91	
Time Poured	[illegible]	7·34	7 45	7 54	
Duration of Pour	[illegible]	45	-	45	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7·29	7·39	7 50	7.50	
Time Probe Down	-	-	-	-	
Time Finish	7 34	7 44	5 55	8 04	
Duration of Probe	5	5	5	5	
Probe Temperature	220	220	220	220	
Probe Steam Pressure	5	5	5	5	
Probe Unit Number	4	4	4	4	

TEST GROUP J
TEST NUMBER 12
TEST DATE 10/3/73

Skid Number	16	17	18	20	

Cooling Bay Data

Cooling Bay - Position	4-5	4-6	4-7	4-10	
Length of Shroud Time	75	81	75	75	
Average Cooling Bay Temp.	90	87	89	86	

X-Ray Results

Number of Shells Poured	52A	60	60	60	
Number of Criticals	0	1	1	0	
Number of Minors	1	4	11	2	
Number of Cavities	2	5	20	3	
Number of Good Shells	51	55	48	58	
Number of Shells with Porosity & Crystallization	0	0	0	0	

A Shells 6, 24, 30, 36, 42, 48, 54, and 60, low pour.

TEST GROUP J
TEST NUMBER 13
TEST DATE 10/3/73

Skid Number	11	19			

Multipour Data (First Pour)

Reservoir Temperature	174	180			
Cup Temperature	174	177			
Material Temperature	175	177			
Shell Temperature	90	90			
Time Poured	6:19	7·50			
Duration of Pour	45	42			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	3-11	4-14			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	94	91			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	4	1			
Number of Minors	6	20			
Number of Cavities	11	22			
Number of Good Shells	50	39			
Number of Shells with Porosity & crystallization	1	0			

TEST GROUP J
TEST NUMBER 14
TEST DATE 10/4/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	175	175	175	175	175
Cup Temperature	174	175	174	175	174
Material Temperature	176	176	176	176	176
Shell Temperature	75	76	76	75	76
Time Poured	5.40	5:44	:49	5:53	5:56
Duration of Pour	115	50	52	51	51
Multipour Number	2	2	2	2	3

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	86	86	86

X-Ray Results

Number of Shells Poured	59A	60	50	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 2 omitted, low pour.

TEST GROUP J
TEST NUMBER 14
TEST DATE 10/4/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	175	175	175	175	175
Cup Temperature	174	174	174	175	174
Material Temperature	176	176	178	177	177
Shell Temperature	77	77	77	77	77
Time Poured	6:00	6·06	6·09	6·13	6:16
Duration of Pour	49	50	45	46	55
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	[illegible]	75
Average Cooling Bay Temp.	86	87	87	[illegible]	87

X-Ray Results

Number of Shells Poured	60	60	60	60	59A
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 15 omitted, low pour.

TEST GROUP J
TEST NUMBER 15
TEST DATE 10/4/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	174	175	175	175	175
Cup Temperature	176	178	179	178	174
Material Temperature	176	176	177	178	175
Shell Temperature	78	78	77	75	76
Time Poured	6:46	6.52	6:56	7·00	7·05
Duration of Pour	90	68	58	45	55
Multipour Number	1	1	1		2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	86	86	87

X-Ray Results

Number of Shells Poured	54A	56B	58C	60	59D
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	54	56	58	60	59
Number of Shells with Porosity & crystallization	0	0	0	0	60

A Shells 15, 21, 26, 31, 33, and 59 omitted, low pour.
B Shells 17, 23, 34, and 53 omitted, low pour.
C Shells 10 and 29 omitted, low pour.
D Shell 2 omitted, low pour.

TEST GROUP J
TEST NUMBER 15
TEST DATE 10/4/73

Skid Number	16	17	18	19	20

Multipour Data

Reservoir Temperature	174	176	178	180	180
Cup Temperature	174	176	174	174	174
Material Temperature	175	176	177	176	177
Shell Temperature	77	76	78	77	77
Time Poured	7:11	7 17	7 21	7 28	7:36
Duration of Pour	47	[illegible]	45	45	47
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-4	4-5	4-6
Length of Shroud Time	78	75	75	75	75
Average Cooling Bay Temp.	87	86	86	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	59A
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	1	0	0
Number of Good Shells	60	60	60	60	59
Number of Shells with Porosity & crystallization	0	0	1	0	0

A Shell 36 omitted, low pour.

TEST GROUP J
TEST NUMBER 16
TEST DATE 10/5/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	174	174	174	178	177
Cup Temperature	175	175	175	175	175
Material Temperature	177	177	176	177	177
Shell Temperature	75	76	76	75	76
Time Poured	1 50	1 53	1 56	2 16	2:19
Duration of Pour	-	-	-	57	49
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-1	4-2	4-3	4-4	4-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.			95		95

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 16
TEST DATE 10/5/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	177	177	176	176	176
Cup Temperature	17[illegible]	176	177	176	176
Material Temperature	177	177	177	178	179
Shell Temperature	77	76	77	76	75
Time Poured	2:23	2:25	2:28	2:30	2:33
Duration of Pour	48	45	46	-	44
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-6	4-7	4-8	4-9	4-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	95	95	95	95	95

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 16
TEST DATE 10/5/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	177
Material Temperature	177	177	177	177	177
Shell Temperature	76	75	75	76	75
Time Poured	2:35	2:38	2:41	2:44	2:46
Duration of Pour	43	-	57	47	50
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-11	4-12	4-13	4-14	5-1
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	95	95		95	-

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 16
TEST DATE 10/5/73

Skid Number	16	17			

Multipour Data

Reservoir Temperature	176	176			
Cup Temperature	177	177			
Material Temperature	177	177			
Shell Temperature	75	75			
Time Poured	2:49	2:52			
Duration of Pour	48	47			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	5-2	3-14			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	89	96			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	0	0			
Number of Minors	0	0			
Number of Cavities	0	0			
Number of Good Shells	60	60			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP J
TEST NUMBER 17
TEST DATE 10/8/73

Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	184	184	184	182	182
Cup Temperature	180	178	178	178	179
Material Temperature	180	180	181	180	179
Shell Temperature	78	76	75	76	76
Time Poured	5:34	5:37	5:40	5:45	5:49
Duration of Pour	40	40	41	38	40
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-1	4-2	4-3	4-4	4-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	89	89	89	89	89

X-Ray Results

Number of Shells Poured	60	60	58A	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	58	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shells 49 and 55 omitted.

TEST GROUP J
TEST NUMBER 18
TEST DATE 10/8/73

Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	182	182	182	182	182
Cup Temperature	180	180	170	180	180
Material Temperature	180	180	180	180	180
Shell Temperature	85	84	85	84	82
Time Poured	6:01	6:05	6:06	6:09	6:12
Duration of Pour	41	40	44	43	44
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-6	4-7	4-8	4-9	4-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	90	90	89	89	89

X-Ray Results

Number of Shells Poured	60	60	60	59A	57B
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	1	0	0
Number of Cavities	0	0	1	0	0
Number of Good Shells	60	60	59	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 42 was omitted from the test.
B Shells 5, 36, and 42 were omitted from the test.

TEST GROUP J
TEST NUMBER 19
TEST DATE 10/8/73

Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	186	187	190	190	190
Cup Temperature	179	182	184	184	184
Material Temperature	182	184	184	183	183
Shell Temperature	76	76	77	76	78
Time Poured	6:56	7:01	7:12	7:17	7:20
Duration of Pour	45	40	43	44	42
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-11	4-12	4-13	4-14	3-1
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	88	88	89	89	86

X-Ray Results

Number of Shells Poured	60	60	60	59A	60
Number of Criticals	0	0	0	0	2
Number of Minors	0	0	0	0	2
Number of Cavities	0	0	0	0	4
Number of Good Shells	60	60	60	59	56
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 19
TEST DATE 10/8/73

Skid Number	21				

Multipour Data (First Pour)

Reservoir Temperature	190				
Cup Temperature	184				
Material Temperature	184				
Shell Temperature	77				
Time Poured	7:39				
Duration of Pour	39				
Multipour Number	2				

Cooling Bay Data

Cooling Bay - Position	3-7				
Length of Shroud Time	75				
Average Cooling Bay Temp.	87				

X-Ray Results

Number of Shells Poured	60				
Number of Criticals	0				
Number of Minors	0				
Number of Cavities	0				
Number of Good Shells	60				
Number of Shells with Porosity & crystallization	0				

TEST GROUP J
TEST NUMBER 20
TEST DATE 10/8/73

Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	190	190	190	190	190
Cup Temperature	184	184	184	184	184
Material Temperature	184	185	185	184	184
Shell Temperature	84	83	84	84	82
Time Poured	7:23	7:27	7:30	7:32	7:35
Duration of Pour	41	40	40	41	39
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-2	3-3	3-4	3-5	3-6
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	87	86	86	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	2	3	0	5	1
Number of Minors	4	0	1	8	0
Number of Cavities	6	3	2	13	1
Number of Good Shells	54	57	59	47	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 20
TEST DATE 10/8/73

Skid Number	22				

Multipour Data

Reservoir Temperature	190				
Cup Temperature	184				
Material Temperature	186				
Shell Temperature	85				
Time Poured	7:42				
Duration of Pour	4				
Multipour Number	2				

Cooling Bay Data

Cooling Bay - Position	3-8				
Length of Shroud Time	75				
Average Cooling Bay Temp.	87				

X-Ray Results

Number of Shells Poured	60				
Number of Criticals	0				
Number of Minors	3				
Number of Cavities	5				
Number of Good Shells	57				
Number of Shells with Porosity & crystallization	0				

TEST GROUP J
TEST NUMBER 21
TEST DATE 10/11/73

Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	178	178	177	177	180
Shell Temperature	79	76	80	77	80
Time Poured	5:20	5:29	5:34	5:41	5:45
Duration of Pour	49	47	43	43	52
Multipour Number	1	1	1	1	1

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	86	8.	86

X-Ray Results

Number of Shells Poured	60	50	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 21
TEST DATE 10/11/73

Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	176	174	174	176	177
Cup Temperature	176	176	176	176	174
Material Temperature	179	179	179	178	179
Shell Temperature	77	78	79	79	79
Time Poured	5:51	5:59	6:07	6:14	6:19
Duration of Pour	35	87	72	60	69
Multipour Number	1	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	87	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP J
TEST NUMBER 21
TEST DATE 10/11/73

Skid Number	11				

Multipour Data

Reservoir Temperature	184				
Cup Temperature	175				
Material Temperature	178				
Shell Temperature	80				
Time Poured	7:03				
Duration of Pour	70				
Multipour Number	2				

Cooling Bay Data

Cooling Bay - Position	3-11				
Length of Shroud Time	[illegible]				
Average Cooling Bay Temp.	85				

X-Ray Results

Number of Shells Poured	60				
Number of Criticals	0				
Number of Minors	0				
Number of Cavities	0				
Number of Good Shells	60				
Number of Shells with Porosity & crystallization	0				

GROUP K

TEST 21

There were 60 critical and 97 minor defects found.

Probe machine 4 had a temporary curtain installed around the sides and the back (about 3 - 4 feet high). The purpose of the curtain was to prevent any drafts from cooling the shells. Skid 17 wss probed in machine 3 which did not have a curtain. The skid had 26 good shells versus the 18 - 20 good shells per skid for the other skids in the test. Skid 17 also had the highest steel temperature of any skid in this test. It is possible that the curtain does not help, but in any case a defect level this high is unacceptable.

TEST 22

There were 10 critical and 44 minor defects found. As in Test 21 three of the four skids were probed in the machine which had a temporary curtain installed around it. The fourth skid (number 8) was probed in unit 3 which did not have a curtain. As in Test 21 the skid had a lower percentage of defective shells.

TEST 23

There were 11 criticals and 33 minor defects found on the 2 skids in this test.

GROUP K PROBING

Test	Probe Time	Number of Skids
21	5	4
22	15	4
23	No probe	1

NOTES:

1. Material containing 40% scrap was used.
2. An additional agitator was used in the reservoir and a minimum lower level limit was maintained.
3. Steel temperature was 88° to 92°F.
4. Explosive temperature was 178 to 182°F.
5. Picatinny shroud was used.
6. The cooling bay temperature was ambient and recorded.
7. Shroud time was 1.25 hours from time of pour.
8. Total cooling time was 3.75 hours.
9. All shells were 100% X-rayed.
10. The probe depth was 4 inches above the breakoff point.
11. Probing was started 5+1 minutes after pouring.
12. The bottom of the probe machine was curtained off while probing except for 1 skid in Test 22.

TEST GROUP K
TEST NUMBER 21
TEST DATE 10/9/73

Skid Number	16	17	18	19	

Multipour Data (First Pour)

Reservoir Temperature	183	184	184	184	
Cup Temperature	182	182	180	182	
Material Temperature	180	180	180	180	
Shell Temperature	91	90	89	91	
Time Poured	7:32	7:35	7:38	7:45	
Duration of Pour	43	41	40	38	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	7:37	7:40	7:43	7:50	
Time Probe Down	0	0	0	0	
Time Finish	7:42	7:45	7:48	7:55	
Duration of Probe	5	5	5	5	
Probe Temperature	-	-	-	-	
Probe Steam Pressure	5	-	5	5	
Probe Unit Number	4	3	4	4	

TEST GROUP K
TEST NUMBER 21
TEST DATE 10/9/73

Skid Number	16	17	18	19	

Cooling Bay Data

Cooling Bay - Position	4-4	3-13	4-5	4-6	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	90	92	91	91	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	15	12	13	20	
Number of Minors	27	22	27	21	
Number of Cavities	42	35	43	41	
Number of Good Shells	18	26	20	19	
Number of Shells with Porosity & Crystallization	0	0	0	0	

TEST GROUP K
TEST NUMBER 22
TEST DATE 10/9/73

Skid Number	1	5	8	12	

Multipour Data (First Pour)

Reservoir Temperature	182	182	182	183	
Cup Temperature	176	180	180	180	
Material Temperature	179	179	179	160	
Shell Temperature	90	90	90	85	
Time Poured	5·31	5 54	6:03	7:07	
Duration of Pour	40	45	45	41	
Multipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	-	-	-	-	
Cup Temperature	-	-	-	-	
Material Temperature	-	-	-	-	
Time Poured	-	-	-	-	
Duration of Pour	-	-	-	-	
Multipour Number	-	-	-	-	

Core Melting Data

Time Start	5.36	5:59	6:08	7:12	
Time Probe Down	-	-	-	-	
Time Finish	5:51	6.14	6:23	7:27	
Duration of Probe	15	15	15	15	
Probe Temperature	220	-	-	-	
Probe Steam Pressure	5	5	8	5	
Probe Unit Number	4	4	3	4	

TEST GROUP K
TEST NUMBER 22
TEST DATE 10/9/73

Skid Number	1	5	8	12	

Cooling Bay Data

Cooling Bay - Position	4-1	4-2	3-5	4-3	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	91	91	92	91	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	3	1	3	3	
Number of Minors	12	7	8	17	
Number of Cavities	15	8	11	20	
Number of Good Shells	45	42	49	40	
Number of Shells with Porosity & Crystallization	0	0	0		

TEST GROUP K
TEST NUMBER 23
TEST DATE 10/9/73

Skid Number	6	20			

Multipour Data

Reservoir Temperature	182	184			
Cup Temperature	180	182			
Material Temperature	179	182			
Shell Temperature	-	90			
Time Poured	5:57	7:48			
Duration of Pour	45	40			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	3-4	3-14			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	92	92			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	3	9			
Number of Minors	12	21			
Number of Cavities	15	30			
Number of Good Shells	45	30			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP L
TEST NUMBER 1
TEST DATE 10/9/73

Skid Number	2	3	4		

Multipour Data

Reservoir Temperature	182	182	182		
Cup Temperature	177	178	178		
Material Temperature	180	179	179		
Shell Temperature	90	91	90		
Time Poured	5:36	5:44	5:49		
Duration of Pour*	15/30	13/28	14/31		
Multipour Number	2	2	2		

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3		
Length of Shroud Time	75	75	75		
Average Cooling Bay Temp.	92	92	92		

X-Ray Results

Number of Shells Poured	60	60	60		
Number of Criticals	17	17	0		
Number of Minors	16	6	0		
Number of Cavities	33	23	0		
Number of Good Shells	27	37	60		
Number of Shells with Porosity & crystallization	0	0	0		

*First pour/second pour

TEST GROUP L
TEST NUMBER 2
TEST DATE 10/9/73

Skid Number	9	10	11		

Multipour Data

Reservoir Temperature	184	182	183		
Cup Temperature	180	180	180		
Material Temperature	180	180	180		
Shell Temperature	90	90	90		
Time Poured	6:44	6:51	6:56		
Duration of Pour *	13/38	13/31	14/31		
Multipour Number	2	2	2		

Cooling Bay Data

Cooling Bay - Position	3-6	3-9	3-8		
Length of Shroud Time	75	75	75		
Average Cooling Bay Temp.	92	92	92		

X-Ray Results

Number of Shells Poured	60	60	60		
Number of Criticals	19	13	13		
Number of Minors	17	12	19		
Number of Cavities	36	25	32		
Number of Good Shells	24	35	28		
Number of Shells with Porosity & crystallization	0	0	0		

*First pour/second pour

TEST GROUP L
TEST NUMBER 3
TEST DATE 10/9/73

Skid Number	13	14	15		

Multipour Data

Reservoir Temperature	183	183	183		
Cup Temperature	180	180	180		
Material Temperature	180	182	180		
Shell Temperature	91	90	90		
Time Poured	7:11	7:18	7:24		
Duration of Pour*	12/27	13/29	13/27		
Multipour Number	2	2	2		

Cooling Bay Data

Cooling Bay - Position	3-10	3-11	3-12		
Length of Shroud Time	75	75	75		
Average Cooling Bay Temp.	92	93	93		

X-Ray Results

Number of Shells Poured	60	60	60		
Number of Criticals	14	9	17		
Number of Minors	23	17	25		
Number of Cavities	37	27	42		
Number of Good Shells	23	34	18		
Number of Shells with Porosity & crystallization	0	0	1		

*First pour/second pour

TEST GROUP L
TEST NUMBER 3
TEST DATE 10/9/73

Skid Number	13	14	15		

Multipour Data

Reservoir Temperature	183	183	183		
Cup Temperature	180	180	180		
Material Temperature	180	182	180		
Shell Temperature	91	90	90		
Time Poured	7:11	7:18	7:24		
Duration of Pour*	12/27	13/29	13/27		
Multipour Number	2	2	2		

Cooling Bay Data

Cooling Bay - Position	3-10	3-11	3-12		
Length of Shroud Time	75	75	75		
Average Cooling Bay Temp.	92	93	93		

X-Ray Results

Number of Shells Poured	60	60	60		
Number of Criticals	14	9	17		
Number of Minors	23	17	25		
Number of Cavities	37	27	42		
Number of Good Shells	23	34	18		
Number of Shells with Porosity & crystallization	0	0	1		

*First pour/second pour

TEST GROUP M
TEST NUMBER 1
TEST DATE 10/10/73

Skid Number	1	2	3	4	

Multipour Data

Reservoir Temperature	186	182	182	180	
Cup Temperature	172	174	174	174	
Material Temperature	179	179	179	179	
Shell Temperature	83	82	83	83	
Time Poured	5:35	5:38	5:42	5:45	
Duration of Pour	39	42	41	45	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	88	88	88	88	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	4	0	2	0	
Number of Minors	4	0	0	3	
Number of Cavities	10	0	2	1	
Number of Good Shells	52	60	58	57	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP M
TEST NUMBER 2
TEST DATE 10/10/73

Skid Number	5	6	7	8	

Multipour Data

Reservoir Temperature	180	182	182	182	
Cup Temperature	177	178	180	180	
Material Temperature	178	180	179	179	
Shell Temperature	82	84	84	85	
Time Poured	5:59	6:02	6:06	6:09	
Duration of Pour	41	43	46	45	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	88	88	88	88	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	2	
Number of Minors	0	0	0	2	
Number of Cavities	0	0	0	4	
Number of Good Shells	60	60	60	56	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP M
TEST NUMBER 3
TEST DATE 10/10/73

Skid Number	11	13			

Multipour Data (First Pour)

Reservoir Temperature	181	182			
Cup Temperature	180	180			
Material Temperature	180	160			
Shell Temperature	86	89			
Time Poured	6:48	7:06			
Duration of Pour	45	46			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	3-11	3-12			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	88	89			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	2	18			
Number of Minors	1	15			
Number of Cavities	3	33			
Number of Good Shells	57	27			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP M
TEST NUMBER 4
TEST DATE 10/10/73

Skid Number	9	10			

Multipour Data

Reservoir Temperature	182	181			
Cup Temperature	180	180			
Material Temperature	180	180			
Shell Temperature	86	86			
Time Poured	6:40	6:43			
Duration of Pour	44	45			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	3-9	3-10			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	88	88			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	0	1			
Number of Minors	3	0			
Number of Cavities	3	1			
Number of Good Shells	60	59			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP M
TEST NUMBER 5
TEST DATE 10/10/73

Skid Number	14	15			

Multipou- Data (First Pour)

Reservoir Temperature	185	186			
Cup Temperature	179	180			
Material Temperature	184	183			
Shell Temperature	84	83			
Time Poured	7:18	7:25			
Duration of Pour	39	40			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	3-13	3-14			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	89	89			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	2	0			
Number of Minors		10			
Number of Cavities	7	10			
Number of Good Shells	53	50			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP M
TEST NUMBER 6
TEST DATE 10/10/73

Skid Number	16	17			

Multipour Data (First Pour)

Reservoir Temperature	186	185			
Cup Temperature	180	180			
Material Temperature	184	184			
Shell Temperature	84	84			
Time Poured	7:28	7:31			
Duration of Pour	39	39			
Multipour Number	2	2			

Cooling Bay Data

Cooling Bay - Position	4-1	4-2			
Length of Shroud Time	75	75			
Average Cooling Bay Temp.	87	87			

X-Ray Results

Number of Shells Poured	60	60			
Number of Criticals	0	1			
Number of Minors	4	9			
Number of Cavities	4	10			
Number of Good Shells	56	50			
Number of Shells with Porosity & crystallization	0	0			

TEST GROUP N
TEST NUMBER 1
TEST DATE 10/12/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	176	177	177	177	177
Cup Temperature	177	177	177	177	177
Material Temperature	176	176	176	175	175
Shell Temperature	75	76	75	75	74
Time Poured	2:17	2:21	2:25	2:30	2:35
Duration of Pour	58	62	64	67	49
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-8	3-10	3-12
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	86	85	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP N
TEST NUMBER 1
TEST DATE 10/12/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	177	177	177	177	177
Cup Temperature	177	177	177	177	177
Material Temperature	175	176	176	176	[illegible]
Shell Temperature	75	76	75	75	75
Time Poured	2:40	2:46	2:52	2:55	
Duration of Pour	72	65	52	53	52
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-14	4-2	4-4	4-6	4-7
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	85	86	86	86	86

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP N
TEST NUMBER 1
TEST DATE 10/12/73

Skid Number	11	[illegible]	13	14	15
Multipour Data (First Pour)					
Reservoir Temperature	177	177	177	176	176
Cup Temperature	177	177	177	176	176
Material Temperature	177	176	177	177	177
Shell Temperature	74	74	75	75	74
Time Poured	3:02	3·06	3:10	3·13	3:16
Duration of Pour	51	55	49	65	47
Multipour Number	2	2	2	2	2
Cooling Bay Data					
Cooling Bay - Position	4-10	4-12	4-12	4-14	5-2
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	87	86	86	83
X-Ray Results					
Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP N
TEST NUMBER 1
TEST DATE 10/12/73

Skid Number	16	17	18	19	
Multipour Data (First Pour)					
Reservoir Temperature	176	177	177	177	
Cup Temperature	177	176	176	176	
Material Temperature	177	177	177	177	
Shell Temperature	75	75	75	75	
Time Poured	3:19	3:23	3:26	3:29	
Duration of Pour	45	50	48	-	
Multipour Number	2	2	2	2	
Cooling Bay Data					
Cooling Bay - Position	5-3	5-5	5-7	5-8	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	83	83	84	84	
X-Ray Results					
Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP 0
TEST NUMBER 1
TEST DATE 10/15/73

Skid Number	1	2	3	4	

Multipour Data

Reservoir Temperature	179	180	180	180	
Cup Temperature	180	180	180	180	
Material Temperature	180	180	180	180	
Shell Temperature	80	80	80	80	
Time Poured	5:49	5 52	5:55	5:59	
Duration of Pour	38	40	40	40	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	85	85	85	85	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP 0
TEST NUMBER 2
TEST DATE 10/15/73

Skid Number	5	6	7	8	

Multipour Data

Reservoir Temperature	178	180	180	180	
Cup Temperature	180	180	180	180	
Material Temperature	179	179	180	180	
Shell Temperature	91	90	95	95	
Time Poured	6:18	6 29	6:32	6.37	
Duration of Pour	42	73	52	43	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	84	85	85	85	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP 0
TEST NUMBER 3
TEST DATE 10/15/73

Skid Number	13	14	15	16	

Multipour Data

Reservoir Temperature	190	190	188	188	
Cup Temperature	184	184	184	184	
Material Temperature	185	185	185	184	
Shell Temperature	94	90	94	96	
Time Poured	7:24	7:28	7:31	7:36	
Duration of Pour	34	34	35	36	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-13	3-14	4-1	4-2	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	85	85	86	86	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	1	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	60	60	59	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP 0
TEST NUMBER 4
TEST DATE 10/15/73

Skid Number	9	10	11	12	

Multipour Data

Reservoir Temperature	184	85	186	187	
Cup Temperature	182	182	184	185	
Material Temperature	182	183	182	184	
Shell Temperature	80	80	81	81	
Time Poured	7:00	7:05	7:11	7:17	
Duration of Pour	39	52	42	35	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	85	85	85	85	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP P
TEST NUMBER 1
TEST DATE 10/18/73

Skid Number	1	2	3	4	5

Multipour Data (First Pour)

Reservoir Temperature	174	177	178	178	178
Cup Temperature	179	179	178	179	178
Material Temperature	176	176	176	176	176
Shell Temperature	75	75	75	76	75
Time Poured	5:41	5:45	5:51	5:56	5:59
Duration of Pour	46	85	62	46	47
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	89	89	89	90	90

X-Ray Results

Number of Shells Poured	59A	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	59	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 59 omitted from test, low pour.

TEST GROUP P
TEST NUMBER 2
TEST DATE 10/18/73

Skid Number	6	7	8	9	10

Multipour Data (First Pour)

Reservoir Temperature	178	177	177	176	176
Cup Temperature	178	178	178	178	178
Material Temperature	176	177	176	177	176
Shell Temperature	86	85	85	85	85
Time Poured	6:05	6:11	6:15	6:18	6:22
Duration of Pour	50	47	48	47	47
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	90	90	90	90	90

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	2	2	1	0
Number of Minors	8	2	7	2	1
Number of Cavities	9	4	9	3	1
Number of Good Shells	51	56	51	57	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP P
TEST NUMBER 3
TEST DATE 10/18/73

Skid Number	16	17	18	19	20

Multipour Data (First Pour)

Reservoir Temperature	186	186	186	186	186
Cup Temperature	186	186	185	184	185
Material Temperature	185	185	184	184	184
Shell Temperature	85	85	85	85	84
Time Poured	7:[illegible]	7:27	7:32	7:35	7:39
Duration of Pour	43	48	44	40	41
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-3	4-4	4-5	4-6
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	88	88	88	88	88

X-Ray Results

Number of Shells Poured	60	60	60	60	59A
Number of Criticals	6	0	5	1	0
Number of Minors	8	14	5	11	8
Number of Cavities	16	16	10	12	8
Number of Good Shells	47	46	50	48	51
Number of Shells with Porosity & crystallization	0	0	0	0	0

A Shell 18 omitted from test, low pour.

TEST GROUP P
TEST NUMBER 4
TEST DATE 10/18/73

Skid Number	11	12	13	14	15

Multipour Data (First Pour)

Reservoir Temperature	184	187	186	187	190
Cup Temperature	184	185	186	187	188
Material Temperature	184	184	184	185	185
Shell Temperature	75	75	76	76	76
Time Poured	6:54	6:57	7:01	7:05	7:19
Duration of Pour	75	54	71	42	41
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	88	88	88	88	88

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 1
TEST DATE 10/19/73

Skid Number	10	11	12	13	14

Multipour Data

Reservoir Temperature	183	183	183	181	181
Cup Temperature	181	181	181	179	179
Material Temperature	180	181	181	181	182
Shell Temperature	80	79	81	82	81
Time Poured	2:49	2:51	2:53	2:56	2:59
Duration of Pour	-	-	39	38	4
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-10	4-11	4-12	4-13	4-14
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	85	85	86	86	86

X-Ray Results

Number of Shells Poured	60	60	60		60
Number of Criticals	0	0	0	0	2
Number of Minors	0	0	0	0	1
Number of Cavities	0	0	0	[illegible]	3
Number of Good Shells	60	60	60	60	57
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 2
TEST DATE 10/19/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	182	182	182	182	[illegible]
Cup Temperature	181	181	181	181	181
Material Temperature	179	179	179	180	180
Shell Temperature	81	81	82	81	81
Time Poured	-	45	43	44	41
Duration of Pour	2	2	2	2	2
Multipour Number					

Cooling Bay Data

Cooling Bay - Position	4-1	4-2	4-3	4-4	4-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	87	87	87	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 3
TEST DATE 10/19/73

Skid Number	6	7	8	9	

Multipour Data

Reservoir Temperature	183	182	183	183	
Cup Temperature	181	181	181	181	
Material Temperature	180	180	181	180	
Shell Temperature	81	81	82	80	
Time Poured	2:36	2:39	2:42	2:45	
Duration of Pour	-	38	40	37	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	
Length of Shroud Time	75	75	75	75	
Average Cooling Bay Temp.	87	87	87	87	

X-Ray Results

Number of Shells Poured	60	60	60	60	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	60	60	60	60	
Number of Shells with Porosity & crystallization	0	0	0	0	

TEST GROUP Q
TEST NUMBER 4
TEST DATE 10/23/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	176	176	176	176	175
Cup Temperature	176	176	176	176	176
Material Temperature	176	175	176	176	177
Shell Temperature	79	80	81	80	81
Time Poured	4:54	4:59	5:03	5:08	5:11
Duration of Pour	75	73	90	59	61
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	86	86	86	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 4
TEST DATE 10/23/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	176	176	176	176	176
Shell Temperature	80	81	81	81	81
Time Poured	5:17	5:32	5:35	5:39	5:43
Duration of Pour	66	60	58	55	55
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	87	87	87	87	87

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 5
TEST DATE 10/23/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	174	175	175	174	175
Shell Temperature	81	81	81	81	80
Time Poured	6:13	6:18	6:21	6:25	6:28
Duration of Pour	58	45	62	60	53
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	2-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	85	86	86	86	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 5
TEST DATE 10/23/73

Skid Number	16	17	18	19	20

Multipour Data

Reservoir Temperature	177	178	179	179	180
Cup Temperature	177	177	176	176	176
Material Temperature	176	176	177	177	177
Shell Temperature	82	82	82	83	83
Time Poured	6:35	6:39	6:46	6:49	6:53
Duration of Pour	53	52	50	50	50
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	2-11	2-12	2-12	2-13	2-14
Length of Shroud Time	75	75	76	75	75
Average Cooling Bay Temp.	85	85	85	85	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 6
TEST DATE 10/24/73

Skid Number	11	13	15	17	19

Multipour Data

Reservoir Temperature	182	182	182	182	182
Cup Temperature	180	180	180	180	179
Material Temperature	179	180	182	181	180
Shell Temperature	85	86	86	85	86
Time Poured	6:42	6:48	7:04	7:11	7:20
Duration of Pour	38	36	34	39	37
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	6-2	6-4	6-6	6-8	6-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	81	81	82	82	82

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	0	8	4	0
Number of Minors	0	0	2	0	0
Number of Cavities	1	0	10	4	0
Number of Good Shells	59	60	50	56	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 7
TEST DATE 10/24/73

Skid Number	12	14	16	18	20

Multipour Data

Reservoir Temperature	182	182	182	182	182
Cup Temperature	180	180	180	179	179
Material Temperature	180	180	181	180	180
Shell Temperature	85	85	85	86	87
Time Poured	6:45	6:52	7:08	7:15	7:24
Duration of Pour	36	36	36	36	37
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	6-3	6-5	6-7	6-9	6-11
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	81	82	82	82	82

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	1	4	3	0
Number of Minors	0	0	2	0	0
Number of Cavities	0	1	6	3	0
Number of Good Shells	60	59	54	57	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 8
TEST DATE 10/24/73

Skid Number	1	3	5	7	9

Multipour Data

Reservoir Temperature	182	182	181	180	182
Cup Temperature	180	180	180	180	180
Material Temperature	180	180	180	181	180
Shell Temperature	85	85	85	86	85
Time Poured	5:00	5:29	5:41	5:47	6:57
Duration of Pour	45	37	37	40	37
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-1	4-3	4-5	4-2	4-9
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	90	90	89	89	90

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	0	0	1	0
Number of Minors	1	0	0	0	0
Number of Cavities	2	0	0	1	0
Number of Good Shells	58	60	60	59	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 9
TEST DATE 10/24/73

Skid Number	2	4	6	8	10

Multipour Data

Reservoir Temperature	182	182	181	181	180
Cup Temperature	180	180	180	180	180
Material Temperature	180	180	181	180	180
Shell Temperature	86	86	85	85	85
Time Poured	5:25	5.34	5:44	5 50	6:02
Duration of Pour	36	37	38	37	38
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-4	4-6	4-8	4-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	90	90	89	90	90

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	1	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	1	0	0	0
Number of Good Shells	60	59	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 10
TEST DATE 10/25/73

Skid Number	2	6	10	14	18

Multipour Data

Reservoir Temperature	182	182	182	182	182
Cup Temperature	178	178	180	177	178
Material Temperature	180	180	181	180	182
Shell Temperature	85	84	85	87	86
Time Poured	5:18	5:34	6:04	7:04	7:23
Duration of Pour	39	39	39	37	38
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-2	3-4	3-6	3-8	3-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	84	85	85	86	85

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	1	0	4	6
Number of Minors	0	0	0	4	1
Number of Cavities	0	1	0	8	7
Number of Good Shells	60	59	60	52	53
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 11
TEST DATE 10/25/73

Skid Number	[illegible]	5	9	13	17

Multipour Data

Reservoir Temperature	180	180	182	182	182
Cup Temperature	178	178	179	178	178
Material Temperature	180	180	181	180	182
Shell Temperature	87	85	85	85	86
Time Poured	5·13	5·30	6·00	6 55	7.26
Duration of Pour	40	38	35	51	36
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-1	3-3	3-5	3-7	3-9
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	[illegible]	85	85	86	86

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	2
Number of Minors	1	0	0	0	2
Number of Cavities	1	0	0	0	4
Number of Good Shells	59	60	60	60	56
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 12
TEST DATE 10/25/73

Skid Number	4	8	12	16	20

Multipour Data

Reservoir Temperature	182	182	182	182	180
Cup Temperature	178	179	178	178	176
Material Temperature	180	181	180	180	181
Shell Temperature	86	84	86	85	85
Time Poured	5:25	5:58	6:52	7:15	7:30
Duration of Pour	39	36	37	38	38
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-2	4-4	4-6	4-9	4-11
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	89	88	90	89	89

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	1	0	3	0
Number of Minors	0	1	0	0	1
Number of Cavities	0	2	0	3	1
Number of Good Shells	60	58	60	57	59
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 13
TEST DATE 10/25/73

Skid Number	3	7	11	15	19

Multipour Data

Reservoir Temperature	182	182	182	182	180
Cup Temperature	178	178	178	178	176
Material Temperature	180	180	180	180	182
Shell Temperature	86	85	85	86	85
Time Poured	5:20	5:38	6:41	7:11	7:27
Duration of Pour	40	39	37	38	36
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-1	4-3	4-5	4-7	4-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	89	90	89	89	89

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	1	0	0	1	4
Number of Minors	0	0	0	0	1
Number of Cavities	1	0	0	1	5
Number of Good Shells	59	60	60	59	55
Number of Shells with Porosity & crystallization	0	0	0	0	0

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TEST GROUP Q
TEST NUMBER 14
TEST DATE 10/26/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	172	177	172	177	172
Cup Temperature	182	177	182	177	182
Material Temperature	176	177	176	176	176
Shell Temperature	70	70	70	70	70
Time Poured	1:34	1:35	1:38	1:40	1:43
Duration of Pour	-	-	-	-	-
Multipour Number	1	2	1	2	1

Cooling Bay Data

Cooling Bay - Position	2-13	2-14	3-1	3-2	3-3
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	84	84	84	84	84

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

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TEST GROUP Q
TEST NUMBER 14
TEST DATE 10/26/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	177	172	177	172	177
Cup Temperature	177	182	177	182	177
Material Temperature	177	177	176	177	176
Shell Temperature	70	70	70	70	70
Time Poured	1:45	1:47	1:49	1 53	1:55
Duration of Pour	-	-	-	-	-
Multipour Number	2	1	2	1	2

Cooling Bay Data

Cooling Bay - Position	3-4	3-5	3-6	3-7	3-8
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.	84	84	84	84	84

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 15
TEST DATE 10/30/73

Skid Number	1	2	3	4	5

Multipour Data

Reservoir Temperature	176	178	178	178	178
Cup Temperature	180	177	180	177	180
Material Temperature	177	176	177	176	176
Shell Temperature	62	60	62	62	64
Time Poured	12:54	12.55	12:57	12:59	1 02
Duration of Pour	-	-	-	-	-
Multipour Number	1	2	1	2	1

Cooling Bay Data

Cooling Bay - Position	2-1	2-2	2-3	2-4	2-5
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.					

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 16
TEST DATE 10/30/73

Skid Number	6	7	8	9	10

Multipour Data

Reservoir Temperature	179	178	179	178	179
Cup Temperature	177	180	177	180	177
Material Temperature	176	176	176	176	176
Shell Temperature	70	70	70	71	72
Time Poured	1:04	1:06	1:07	1:10	1:11
Duration of Pour	-	-	-	-	-
Multipour Number	2	1	2	1	2

Cooling Bay Data

Cooling Bay - Position	2-6	2-7	2-8	2-9	2-10
Length of Shroud Time	75	75	75	75	75
Average Cooling Bay Temp.					

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP Q
TEST NUMBER 16
TEST DATE 10/30/73

Skid Number	11	12	13	14	15

Multipour Data

Reservoir Temperature	179	178	178	179	178
Cup Temperature	177	180	180	177	180
Material Temperature	176	176	176	176	176
Shell Temperature	72	73	74	76	74
Time Poured	1:14	1:15	1:18	1:21	1-23
Duration of Pour	-	-	-	-	-
Multipour Number	2	1	1	2	1

Cooling Bay Data

Cooling Bay - Position	2-11	2-12	2-13	2-14	3-1
Length of Shroud Time	75	76	75	75	75
Average Cooling Bay Temp.					

X-Ray Results

Number of Shells Poured	60	60	60	60	60
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	*60	60	60	60	60
Number of Shells with Porosity & crystallization	0	0	0	0	0